Aerospace Operations Systems (AOS)

PROGRAM MANAGEMENT COUNCIL REVIEW

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Aviation Systems Capacity &
Aerospace Operations Systems Programs

October 7, 1999

http://www.aos.nasa.gov/aosbase

Acronyms

3-D	Three-dimensional
AATT	Advanced Air Transportation Technologies
AI	Aircraft Icing
AOS	Aerospace Operations Systems
ARC	Ames Research Center
ASC	Aviation System Capacity
ASIST	Aviation Safety Investment Strategy Team
ASTAC	Aero-Space Technical Advisory Committee
ATM	Air Traffic Management
AvSP	Aviation Safety Program
AWIN	Advanced Weather INformation
CAT	Clear Air Turbulence
CNS	Communication, Navigation & Surveillance
COSTM	Cost-benefit Operational Safety Testing Models
GPRA	Government Performance Review Act
CTAS	Center TRACON Automation System
DFRC	Dryden Flight Research Center
ESC	Executive Steering Committee
FAA	Federal Aviation Administration
FY	Fiscal Year
G&C	Guidance & Control
G/L	Guideline
GRC	Glenn Research Center
HAIR	Human-Automation Integration Research
HF	Human Factors
IT	Information Technology
LaRC	Langley Research Center
LEWICE	LeRC Ice accretion code
MASSS	Methods for Analysis of System Stability & Safety
MOAT	Maintenance, Operations & Training
NAR	Non-Advocate Review
NAS	National Airspace System
NRC	National Research Council
OAT	Office of Aero-Space Technology
OpCon	Operations Concept
PMC	Program Management Council
PPSF	Psychological and Physiological Stressors and Factors
R/C	Rotorcraft
R&T	Research and Technology
SHCT	Short-Haul Civil Tilt-rotor
SLD	Super-cooled Large Droplet
TAP	Terminal Area Productivity
UPN	Universal Program Number
WBS	Work Breakdown Structure

Outline

- **Review Context**
- **Program Overview**
  - Goals & Objectives; Scope; Structure; Milestones; Resources
- **Program Changes**
  - Recent Evolution; Relationship to Aviation Safety Program
- **Project Accomplishments**
  - Aircraft Icing (AI)
  - Aviation Weather Information (AWIN)
  - Human-Automation Integration Research (HAIR)
  - Maintenance Operations and Training (MOAT)
  - Psychological and Physiological Stressors and Factors (PPSF)
  - Methods for Analysis of System Stability and Safety (MASSS)
- **Management**
  - Management Structure
  - Program Assessment
  - Advisory Committee Reporting
  - Future Plans

Baseline for October 1999 AOS PMC Review

- Reviews program performance since January 1999 AOS PMC
- Addresses performance based on April 1998 Program Plan
- Based upon 2000 President's Budget
- Addresses March 1999 and September 1999 AOS ASTAC Subcommittee meetings

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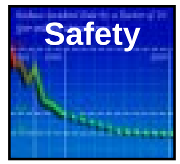
Aerospace Operations Systems Program

Pioneer advanced research and technology to enable revolutionary advances in Aerospace Operations Systems to support NASA Goals:



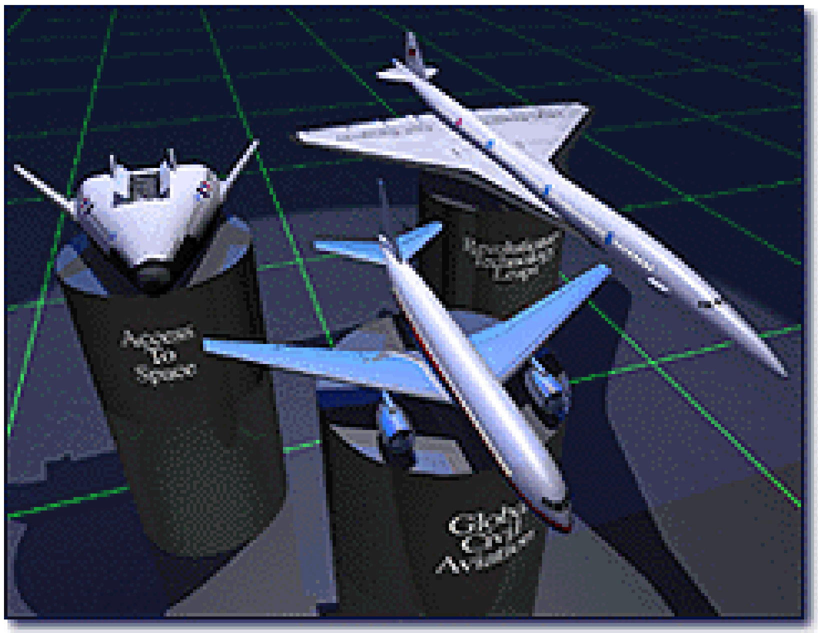
Reduce the aircraft accident rate by a factor of 5 within 10 years, and a factor of 10 within 25 years

While maintaining safety, triple the aviation system throughput, in all weather conditions, within 10 years

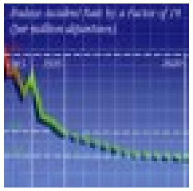
Aerospace Operations Systems are ground, satellite, and vehicle systems, and human operators, that determine the operational safety, efficiency and capacity of vehicles operating in the airspace, including:

- ***communication, navigation and surveillance (CNS) systems;***
- ***air traffic management systems, interfaces and procedures;***
- ***relevant cockpit systems, interfaces and procedures;***
- ***operational human factors, their impact on aviation operations, and error mitigation;***
- ***weather and hazardous environment characterization, detection and avoidance systems***

Aero-space Technology Enterprise "3 Pillars"



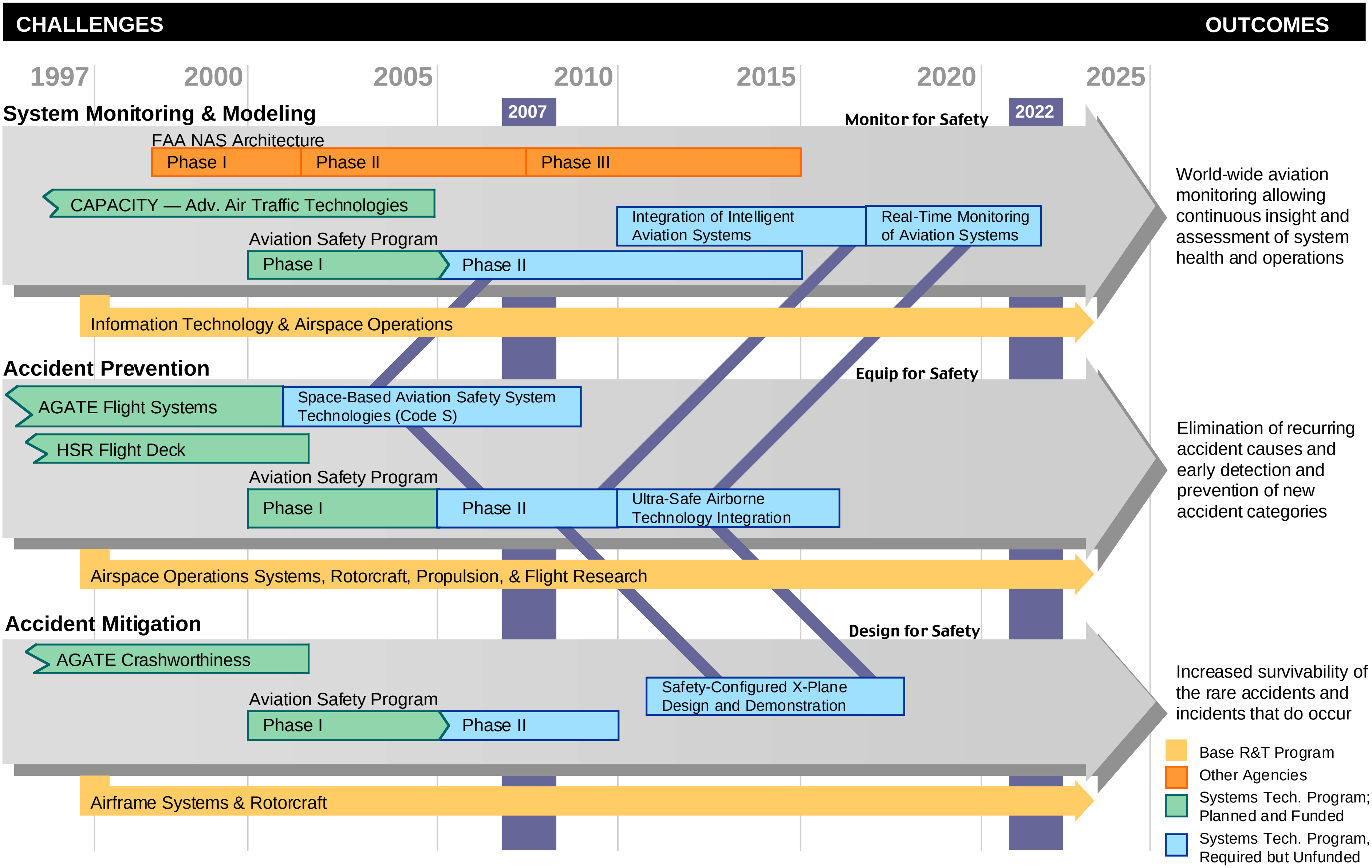
- *Global Civil Aviation*
  - *Five stretch goals*
- *Revolutionary Technology Leaps*
  - *Three stretch goals*
- *Access to Space*
  - *Two stretch goals*



Goal 1: Aviation Safety

Reduce the aircraft accident rate by a factor of five within 10 years, and by a factor of 10 within 25 years

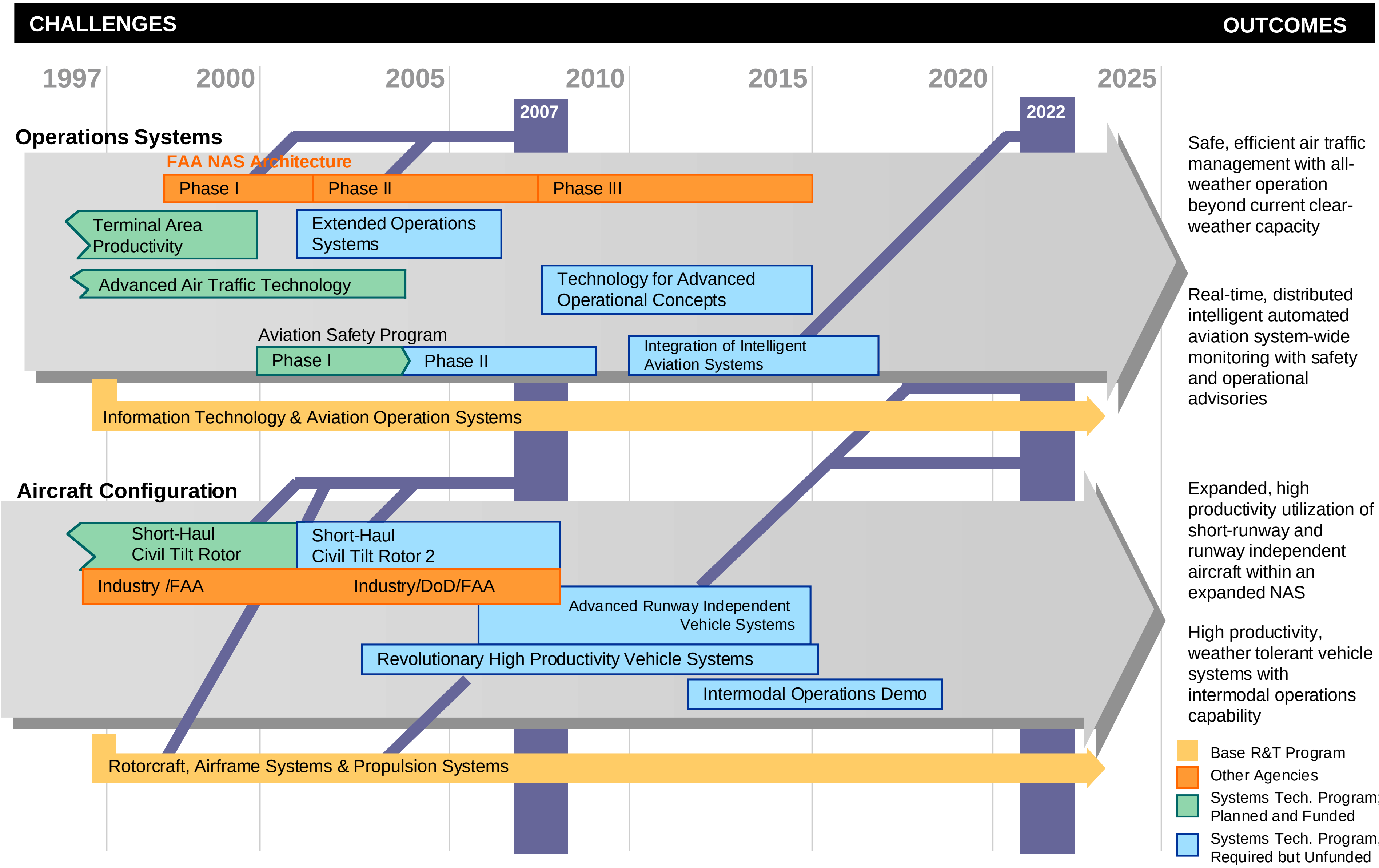
Benefits:
- Safer air transportation worldwide
- Dramatic reduction in aviation fatalities
- Eliminate safety as an inhibitor to a potential tripling of the aviation market



Goal 4: Aviation System Throughput

While maintaining safety, triple the Aviation System throughput, in all weather conditions, within 10 years

Benefits:
- Enable significant improvements to critical transportation infrastructure
- Assure safe, reduced delay flight as air traffic density increases
- Improve mobility for public
- Improve air-traveler's time productivity



Strategic Investment Basis

- NASA OAT Goals and Roadmaps, 1998
- Huettner report, 1997
- ASIST Planning Process, 1997
- NRC Breakthrough Technologies report, 1998
- NRC Human Factors for ATM, 1997
- National Aviation Weather Program Strategic Plan, National Aviation Weather Program Council, 1997
- National Plan for Civil Aviation Human Factors, 1995

AOS Program Structure

- Safety Focus:
  - "Aircraft/Aviation System, People, Environment" (Huettner, 1997)
- Technology Focus Defines Investment Areas:
  - System Design Assessment and Reliability

    address aviation system performance and reliability, including the human operators explicitly, in design and operation
  - Human Performance Countermeasures

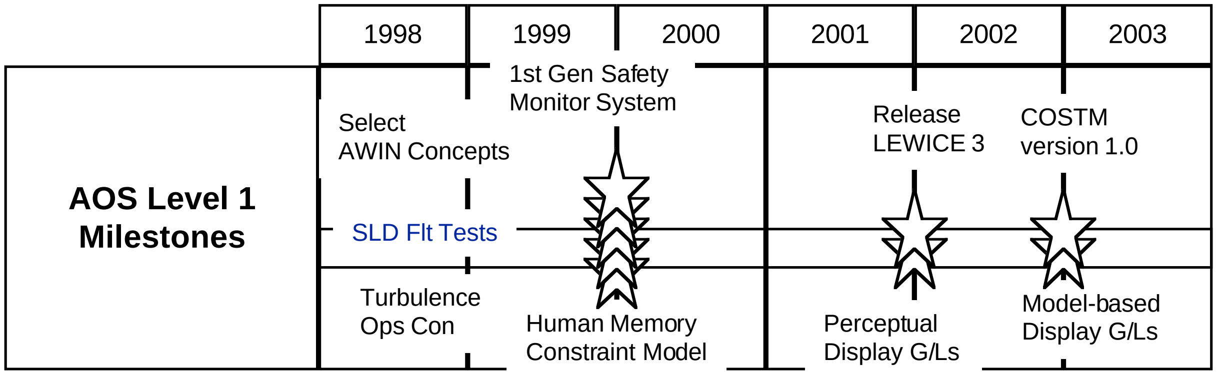
    develop knowledge bases and models of fundamental human information processing capabilities/limits to guide design of technologies to enhance them, or countermeasures to remediate them
  - Hazardous Environment Prediction and Mitigation

    develop databases, knowledge bases, models, and predictive technologies to assess critical weather influences on both safety and efficiency.

AOS Investment Areas and Projects

Investment Areas	Projects
System Design Assessment & Reliability	> HUMAN-AUTOMATION INTEGRATION RESEARCH: HAIR > METHODS FOR ANALYSIS OF SYSTEM STABILITY & SAFETY: MASSS (Moved to AvSP in FY00) > COST-BENEFIT OPERATIONAL SAFETY TESTING MODELS: COSTM (Delayed start to FY01)
Human Performance & Counter-Measures	> MAINTENANCE OPERATIONS, AND TRAINING: MOAT (Partially moved to AvSP in FY00; Fatigue remains) > PSYCHOLOGICAL/PHYSIOLOGICAL STRESSORS & FACTORS: PPSF
Hazardous Environment Prediction & Mitigation	> AIRCRAFT ICING: ICING > AVIATION WEATHER INFORMATION: AWIN (Moved to AvSP in FY00)

Milestones - Level 1



System Design, Assessment & Reliability

- Develop a first-generation, system-wide monitoring capability to measure and communicate the health and status of operational safety performance (FY99)
- Develop model of human memory constraints in reactive planning and procedure execution (FY99)
- Validate model-based display design guidelines in part-task simulation (FY2002)
- Develop COSTM version 1 with integrated human performance and large-scale NAS logistic models (FY2002)

GPRA Milestone

Human Performance and Countermeasures

- Complete guidelines for perceptually matched dynamic 3-D auditory displays and image sensor fusion (FY2001)

Hazardous Environment Prediction and Mitigation

- Define and evaluate operational concepts for all-weather turbulence detection systems (FY99)
- Complete flight tests and instrumentation comparison for the NASA/AES Joint Super-cooled Large Droplet (SLD) icing program (FY99)
- Evaluate and select Aviation Weather Information (AWIN) concepts (FY99)
- Release computational prediction tool LEWICE version 3.0 to industry (FY01)

Technical Progress

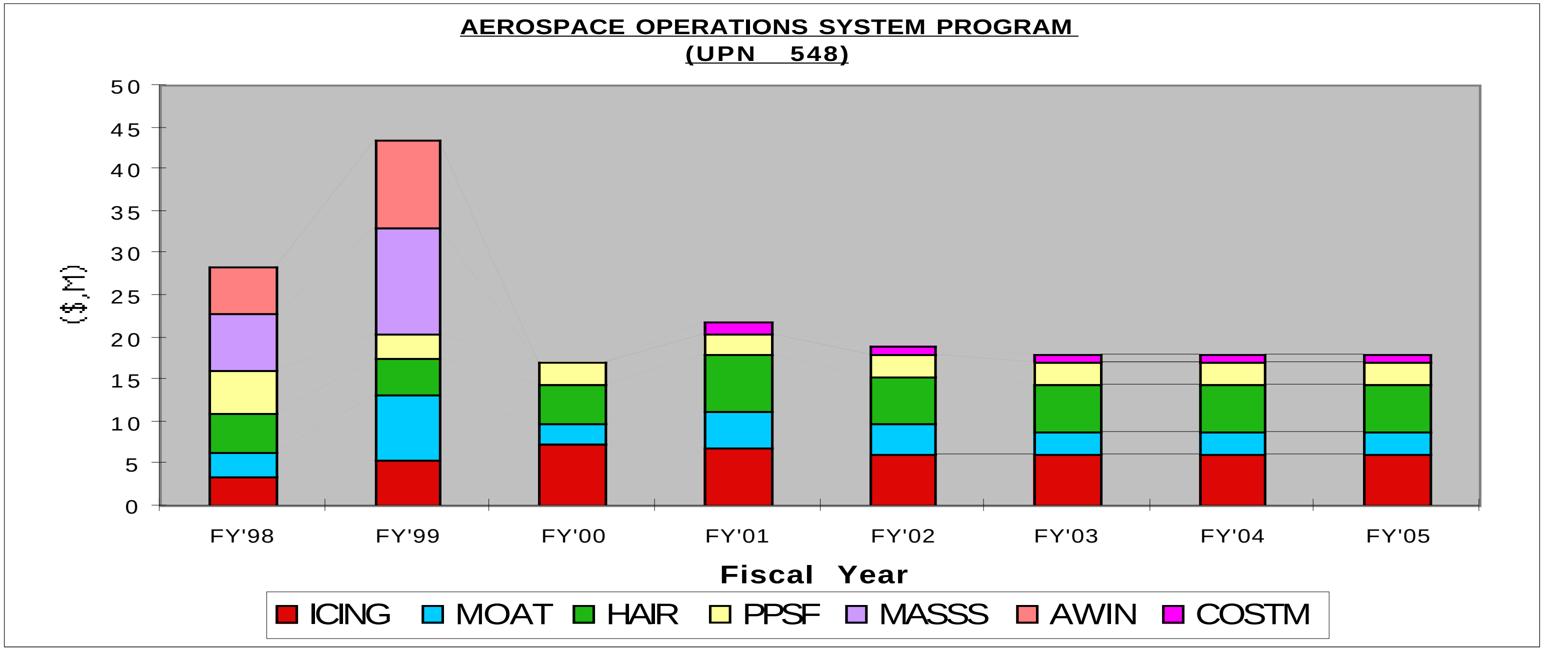
- Completed all 5 FY99 Program-Level Milestones:
  - HAIR: Develop model of human memory constraints in reactive planning and procedure execution
  - MASSS: Demonstrate a first-generation, system-wide monitoring capability to measure and communicate the health and status of operational safety performance
  - Icing: Complete flight tests and instrumentation comparison for the NASA/AES Joint Super-cooled Large Droplet (SLD) icing program
  - AWIN: Evaluate and select Aviation Weather Information concepts
  - AWIN: Define and evaluate operational concepts for all-weather turbulence detection systems

GPRA milestone shown in blue

Budget Status

- At the Code R Budget Superbowl in June, AOS was facing a $4.3M per year baseline budget cut starting in FY00
- This cut was on top of major elements of the AOS Base Program being transferred to the Aviation Safety Program in FY00
- The NASA Office of Aero-Space Technology responded to various reclama by directing NASA Ames to restore the AOS Base Program, except the restoration would start in FY01.
- The $4.3M cut in FY00 will result in the delay of starting a new project

Budget by WBS

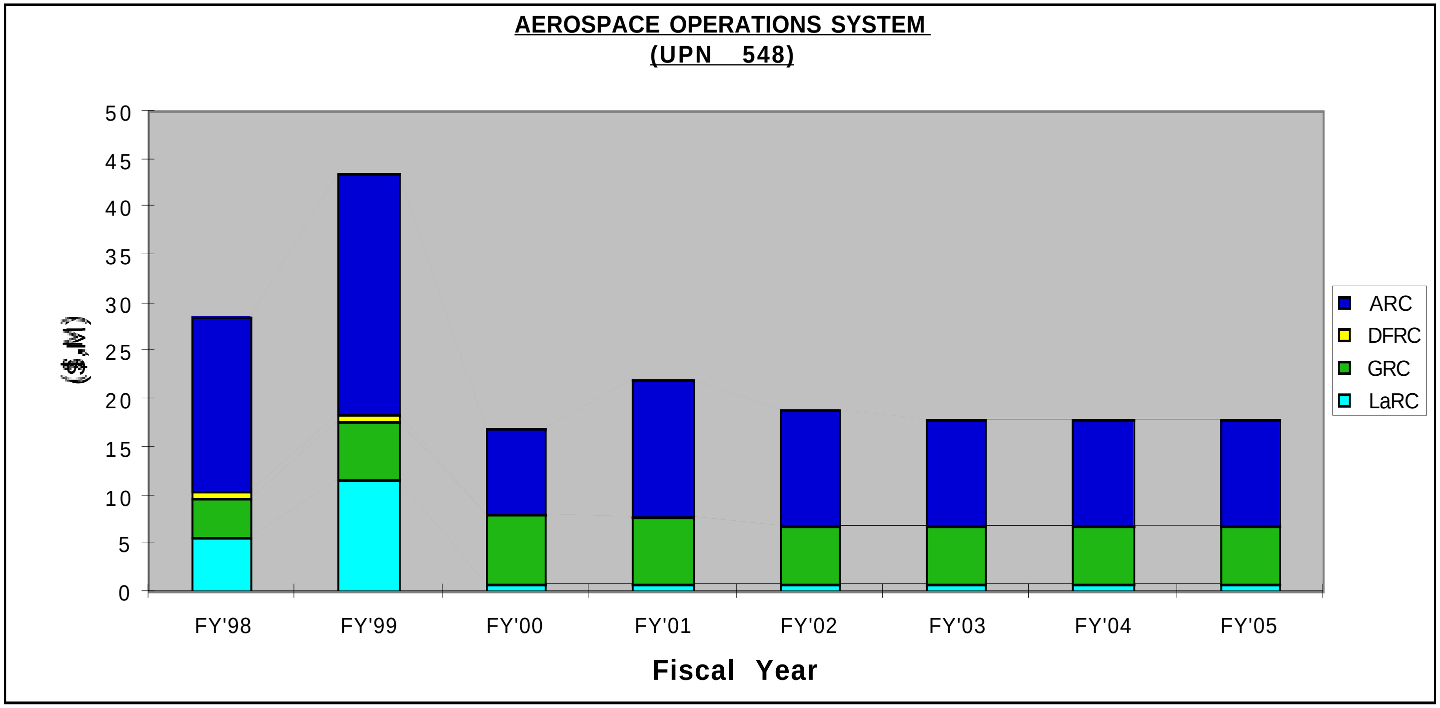


Budget by WBS

WBS	Prior Year FY'98	CY FY'99	CY+1 FY'00	CY+2 FY'01	CY+3 FY'02	CY+4 FY'03	CY+5 FY'04	CY+6 FY'05
ICING	3.4	5.5	7.2	6.9	6.0	6.0	6.0	6.0
MOAT	2.9	7.6	2.5	4.2	3.6	2.8	2.8	2.8
HAIR	4.6	4.3	4.7	6.8	5.7	5.5	5.5	5.5
PPSF	5.3	3.0	2.6	2.6	2.6	2.6	2.6	2.6
MASSS	6.6	12.7	0.0	0.0	0.0	0.0	0.0	0.0
AWIN	5.7	10.3	0.0	0.0	0.0	0.0	0.0	0.0
COSTM	0.0	0.0	0.0	1.4	1.0	1.0	1.0	1.0
Total	28.4	43.4	17.0	21.9	18.9	17.9	17.9	17.9

CY = CURRENT YEAR

Budget by Center

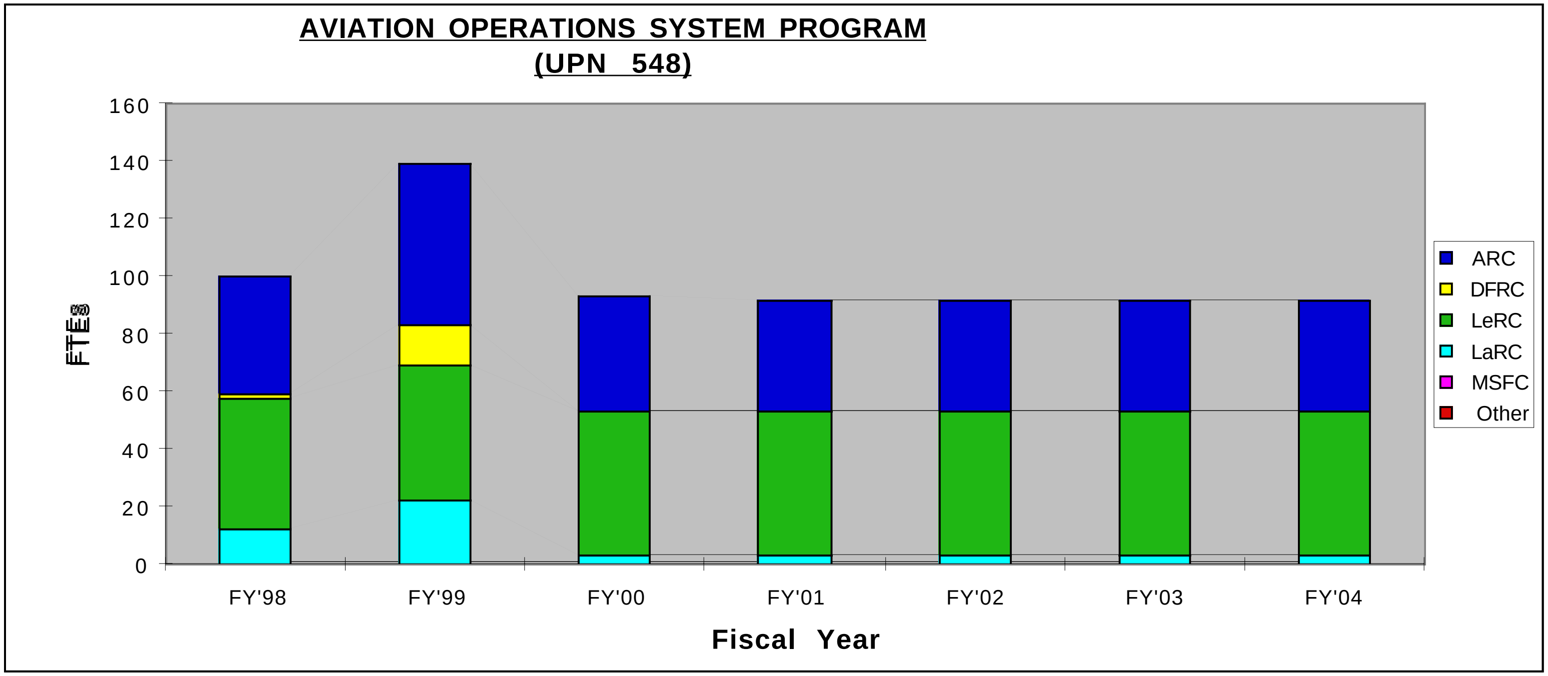


Budget by Center

Center	Prior Year FY'98	CY FY'99	CY+1 FY'00	CY+2 FY'01	CY+3 FY'02	CY+4 FY'03	CY+5 FY'04	CY+6 FY'05
ARC	18.0	25.1	9.1	14.3	12.1	11.1	11.1	11.1
DFRC	0.8	0.7	0.0	0.0	0.0	0.0	0.0	0.0
LaRC	5.5	11.5	0.8	0.8	0.8	0.8	0.8	0.8
GRC	4.1	6.2	7.2	6.9	6.0	6.0	6.0	6.0
Total	28.4	43.4	17.0	21.9	18.9	17.9	17.9	17.9

CY = CURRENT YEAR

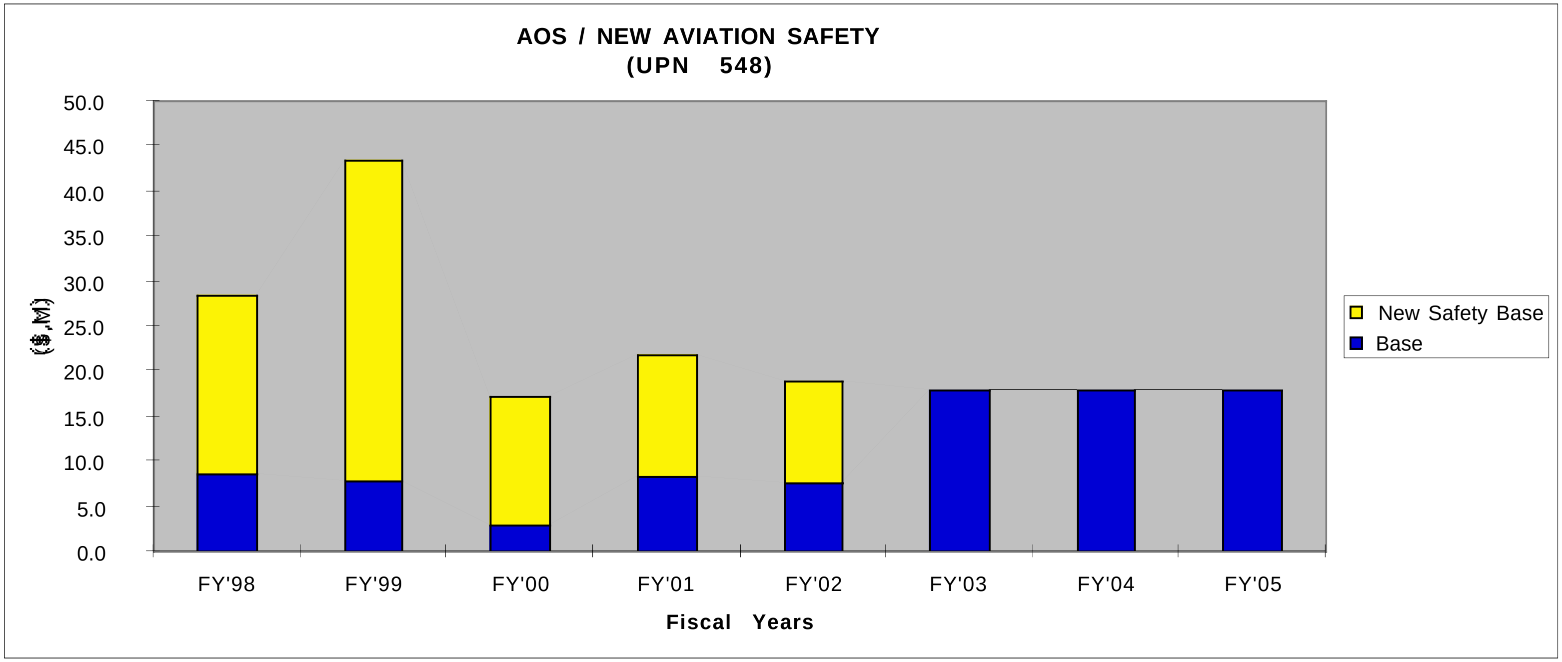
Workforce by Center



Workforce by Center — FY 2000 Budget Submission - 918 Data

Center	Current Year FY'98	CY+1 FY'99	CY+2 FY'00	CY+3 FY'01	CY+4 FY'02	CY+5 FY'03	CY+6 FY'04
ARC	40.9	56.0	39.8	38.2	38.7	38.7	38.7
DFRC	1.0	14.0	0.0	0.0	0.0	0.0	0.0
LaRC	12.0	22.0	3.0	3.0	3.0	3.0	3.0
LeRC	46.0	47.1	50.0	50.0	50.0	50.0	50.0
MSFC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	99.9	139.1	92.8	91.2	91.7	91.7	91.7

AOS Base & Safety Financial Relationship



WBS	Prior Year FY'98	CY FY'99	CY+1 FY'00	CY+2 FY'01	CY+3 FY'02	CY+4 FY'03	CY+5 FY'04	CY+6 FY'05
Base	8.7	7.9	2.9	8.3	7.7	17.9	17.9	17.9
New Safety Base	19.7	35.5	14.1	13.6	11.3	0.0	0.0	0.0
Total	28.4	43.4	17.0	21.9	18.9	17.9	17.9	17.9

CY = CURRENT YEAR

Program Support Evolution

Centers	FY 1998 NET	FY 1998 PS	FY 1998 GROSS	FY 1999 NET	FY 1999 PS	FY 1999 GROSS	FY 2000 NET	FY 2000 PS	FY 2000 GROSS
ARC	11,068	6,943	18,011	16,808	9,134	25,942	5,154	3,898	9,052
DFRC	800	60	860	592	100	692			
LaRC	3,151	2,307	5,458	6,908	3,865	10,773	478	273	751
JSC				75		75			
GRC	3,012	1,100	4,113	3,652	2,124	5,776	5,222	1,975	7,197
HDQ				142		142			
AOS Program	18,031	10,410	28,442	28,177	15,223	43,400	10,854	6,146	17,000

Financial Performance

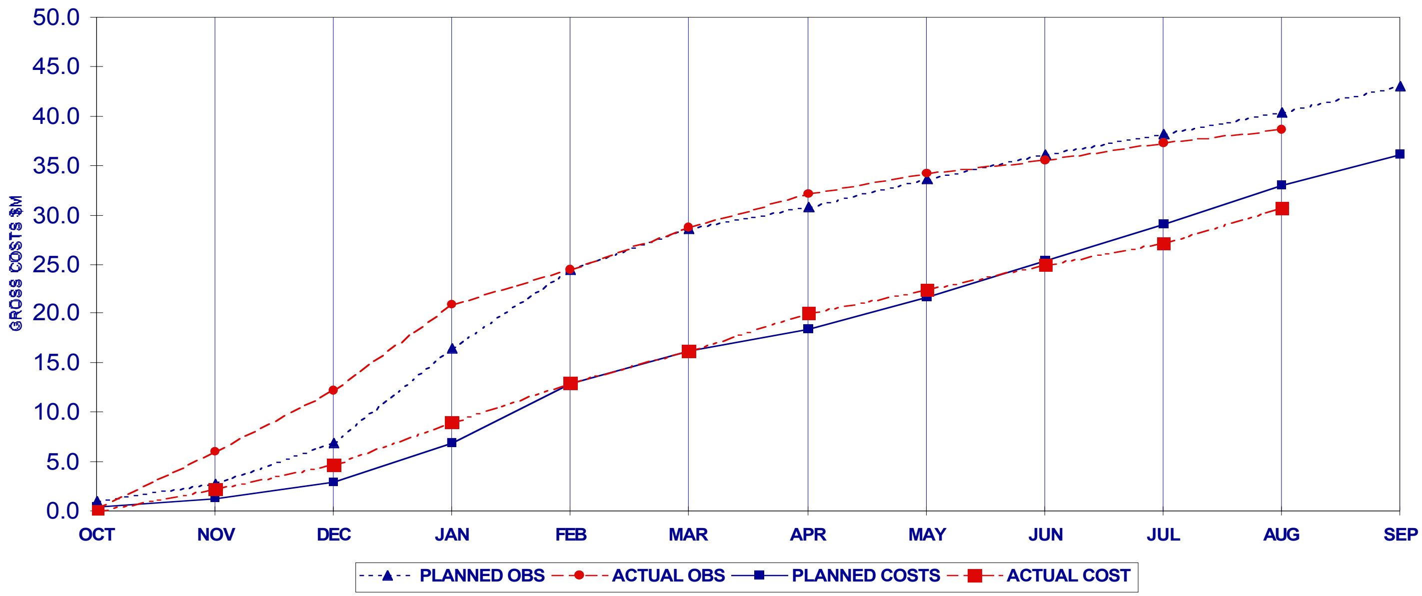
AEROSPACE OPERATIONS SYSTEM PROGRAM: ALL CENTERS

Actuals as of 8/31/99

PY 1999 (GROSS) Obligations/Costs

Guideline: $43,400K

548 Aviation Operations System



All Centers	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
PLANNED OBS	1.0	2.8	6.9	16.6	24.5	28.7	30.9	33.6	36.2	38.3	40.4	43.0
ACTUAL OBS	0.3	6.0	12.2	20.9	24.5	28.7	32.2	34.2	35.5	37.3	38.7	
OB VARIANCE	***-0.6***	***3.3***	***5.2***	***4.3***	***0.0***	***0.0***	***1.3***	***0.6***	***-0.7***	***-1.0***	***-1.7***	
PLANNED COSTS	0.5	1.3	2.9	7.0	12.9	16.2	18.4	21.7	25.4	29.1	33.0	36.1
ACTUAL COST	0.0	2.2	4.7	9.0	12.9	16.2	20.1	22.4	25.0	27.2	30.6	
COST VARIANCE	***-0.5***	***1.0***	***1.8***	***2.0***	***0.0***	***0.0***	***1.7***	***0.8***	***-0.4***	***-1.9***	***-2.4***	
Cost Variance %	***-97.7%***	***75.6%***	***60.9%***	***28.4%***	***0.0%***	***-0.2%***	***9.1%***	***3.5%***	***-1.7%***	***-6.6%***	***-7.2%***	

Variance Explanation: Ames behind Cost -1.6K due to grants and contracts, LaRC behind -4K and LeRC behind -4K due to HSR readjustments of accurals. No programmatic impact.

Financial Performance Issues

- **Program may have loss of funds due to problems at Ames, Code IH:**
  - FAA Battelle Contract is behind $519K due to lateness in receiving accrual documents from the FAA. Code IH financial analysts are still attempting to get the FAA documents to fund Battelle before books for FY99 close next week.
  - Grants and cooperative agreements are behind $165K due to delays in receiving SF272 costing documents from PI's at universities (primarily San Jose State University). Code IH financial analysts are working aggressively to get SF272s from all PI's.

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Aerospace Operations Systems Base R&T Program

AOS Base Program Evolution

< FY95
- Human Factors R&T
- G&C R&T
- Aerody-namics R&T

FY96
- AOS
- R/C
- IT

G. Condon

FY97
- AOS Base
- Safety Plan
- ASIST

Dr. C. Null

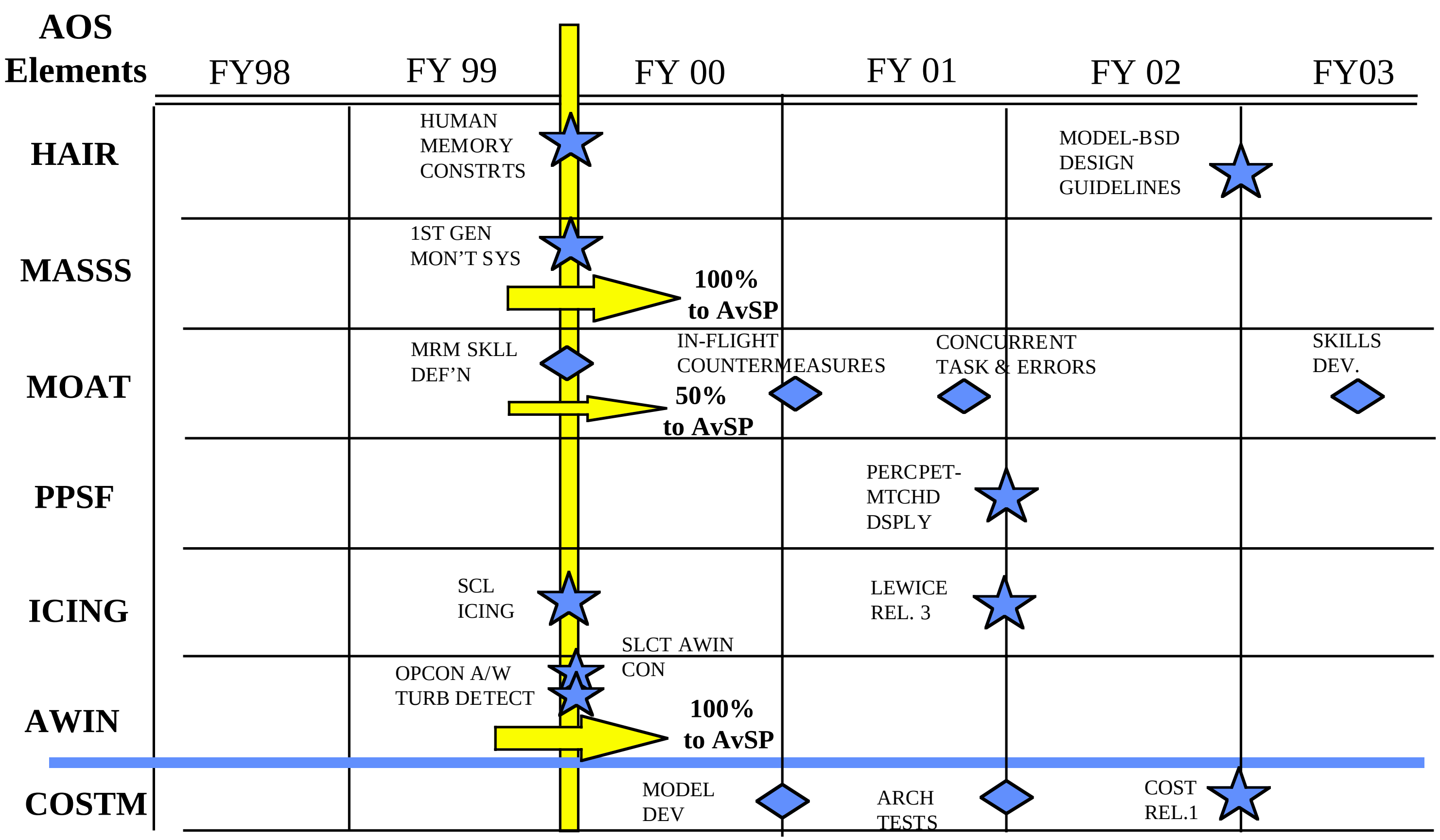
FY98
- AOS Base
- AvSP NAR

Dr. V. Lebacqz

FY00
Aviation Safety

Aerospace Operations Systems

AOS/AvSP Technology Transfer



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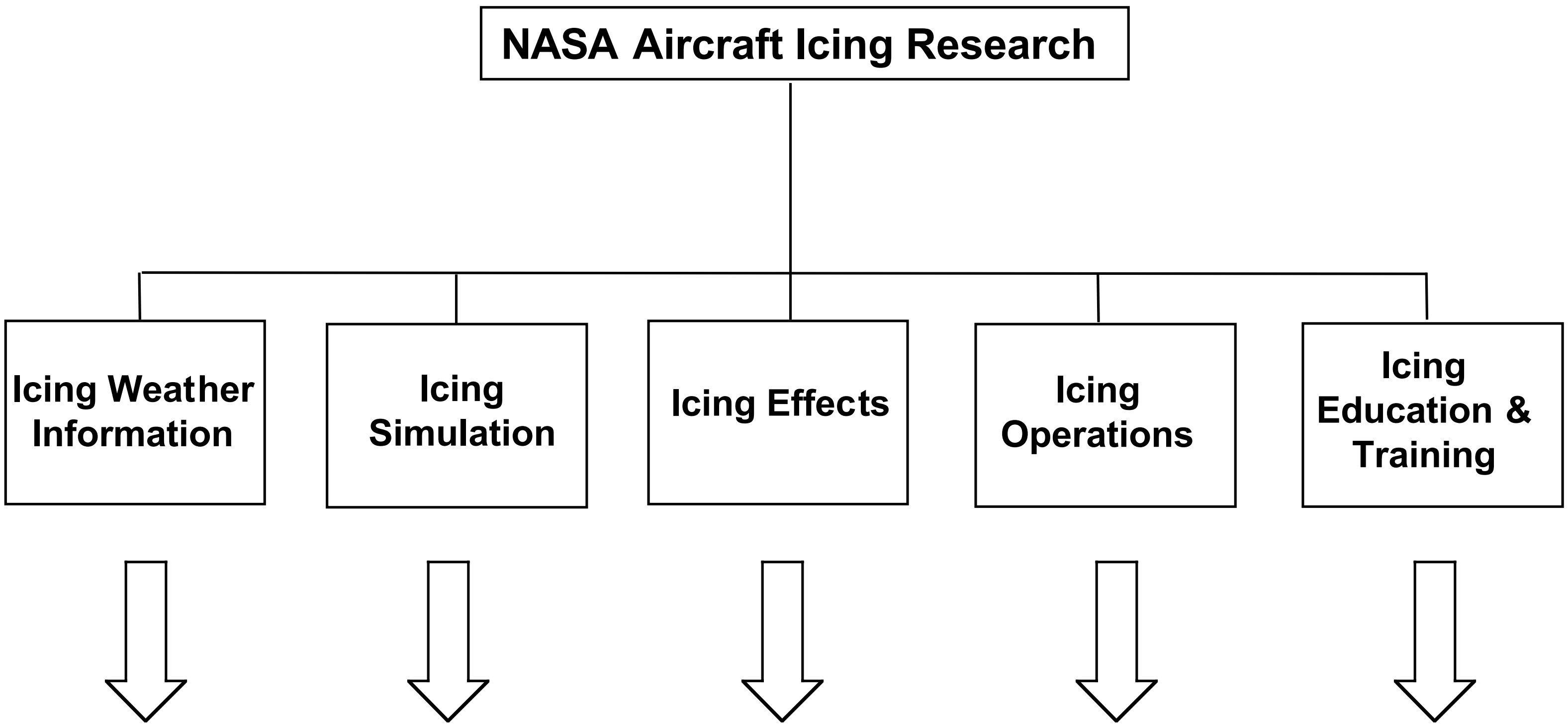
Aircraft Icing

Mary F. Wadel
Glenn Research Center

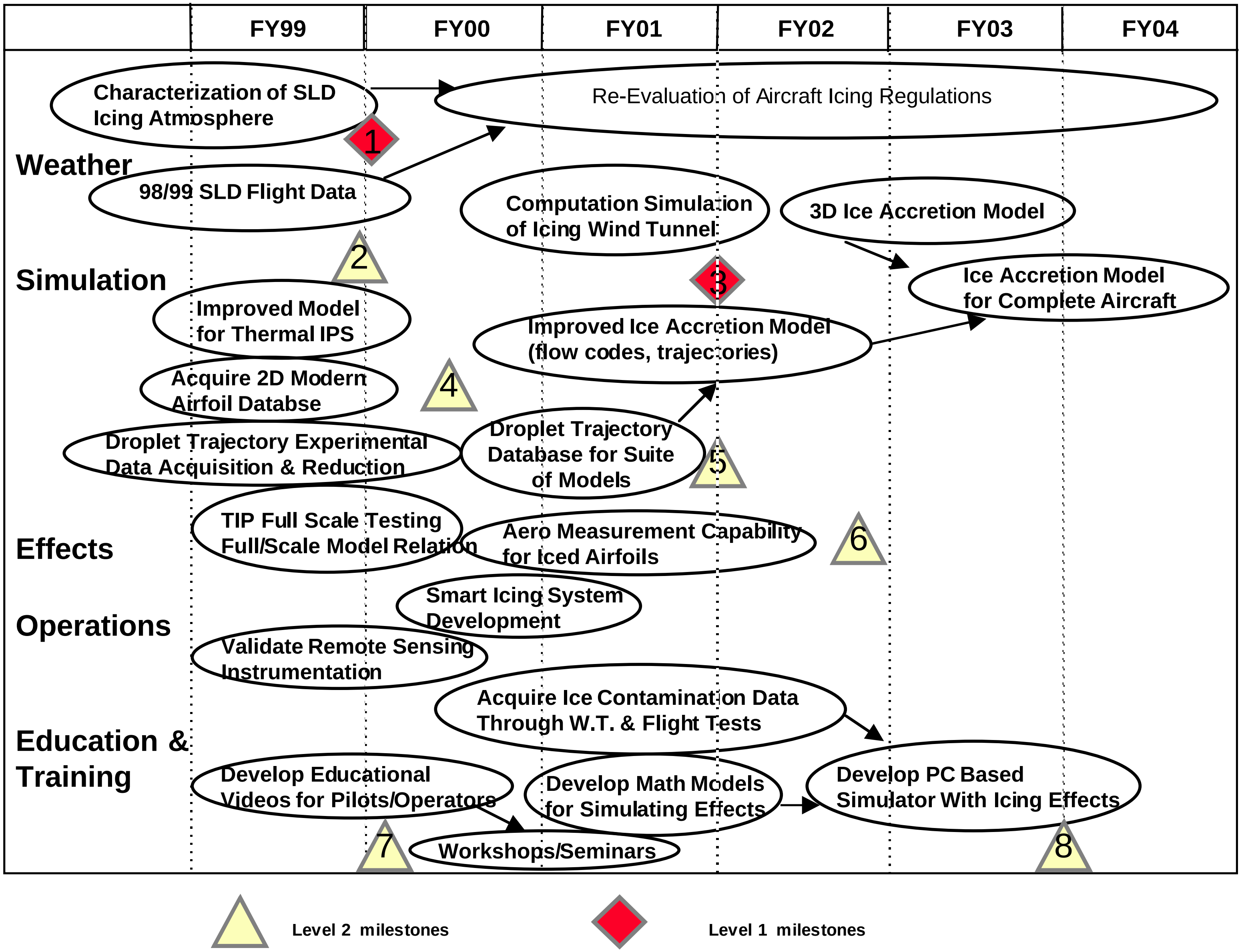
Aircraft Icing Project Approach

Major Technology Elements

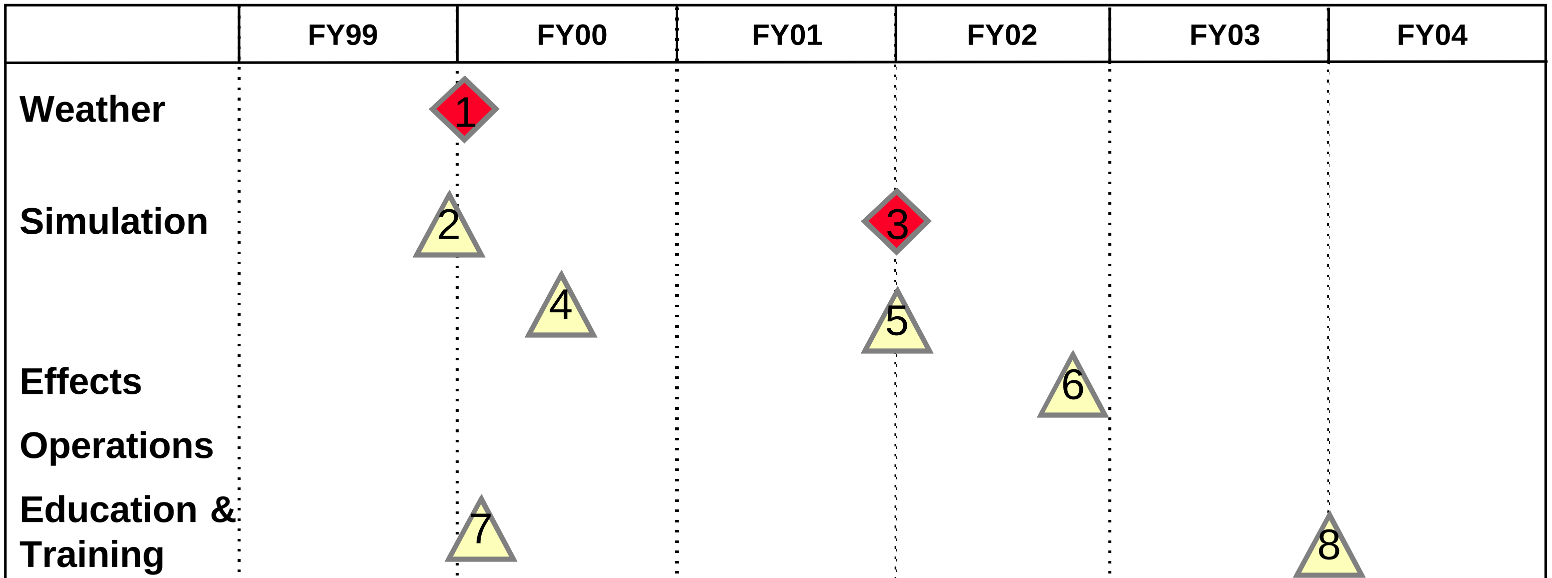


Support NASA Enterprise Goals: Aviation Safety, Capacity, Affordability, and Design Tools

Roadmap & Milestones



Milestone Key

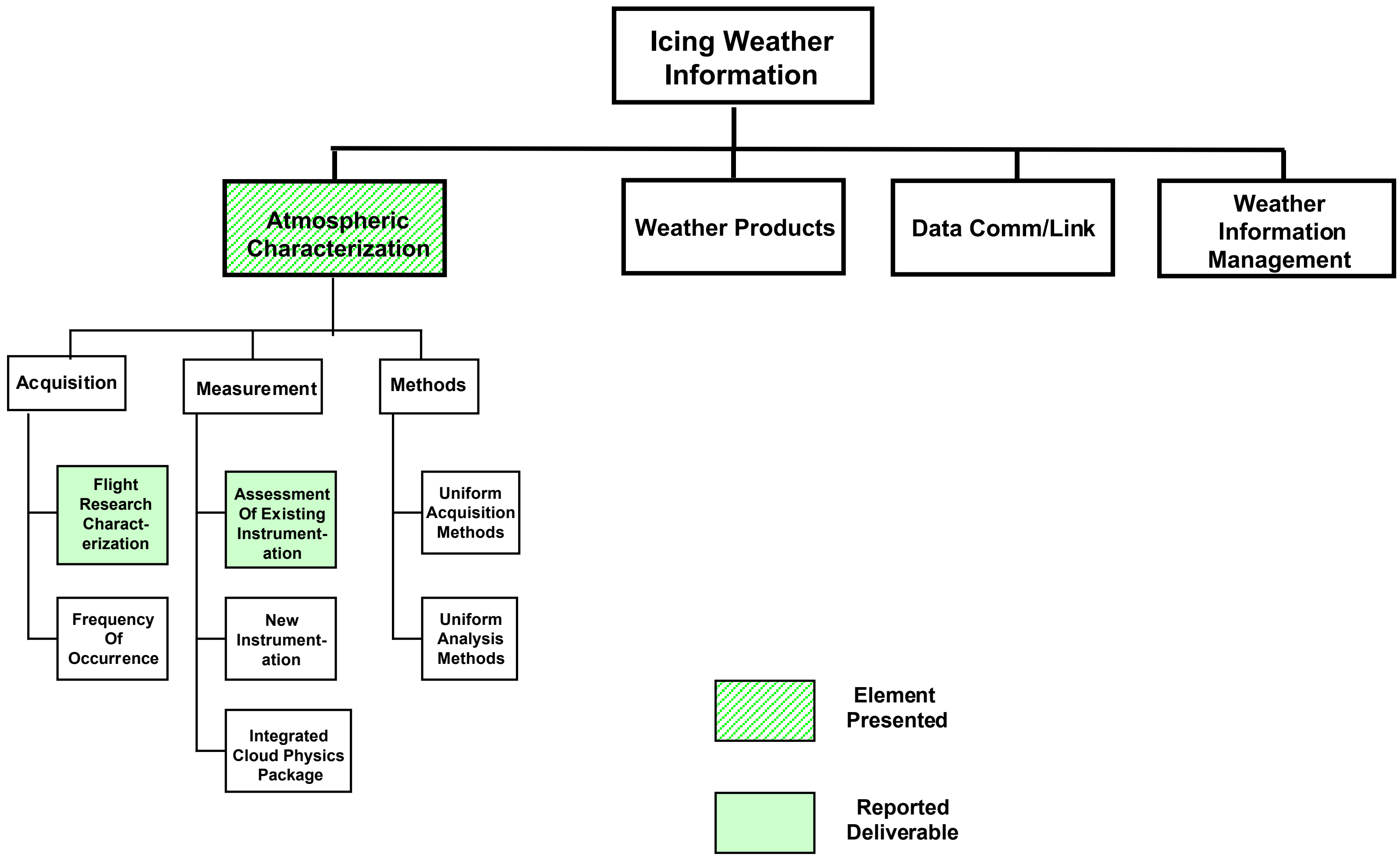


1. Complete flight tests and instrumentation comparison for NASA/AES joint super-cooled large droplet icing program
2. LEWICE Version 2.0 release
3. Release computational prediction tool LEWICE version 3.0 to industry
4. Complete modern airfoil program report; close-out 2D modern airfoil task of NASA Glenn/FAA Tech Center MOA
5. Complete NASA droplet impingement study report
6. Complete Tailplane Icing Program, Phase II
7. Release 2nd in series of icing pilot training videos
8. Provide GA/Commuter community a PC-Based simulator and training module for icing effects in light aircraft

Level 2 milestones

Level 1 milestones

Icing Weather Information Technology Elements

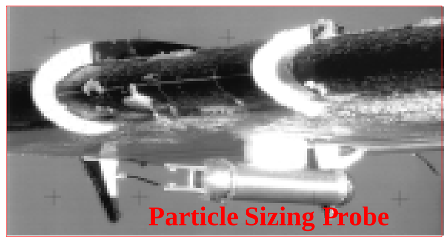


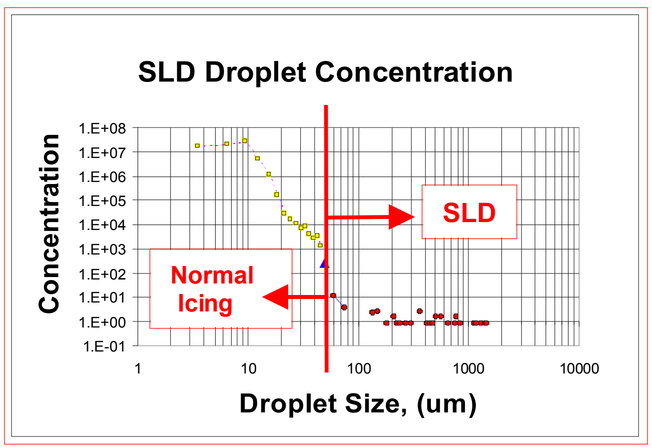
Goals & Objectives

Goal

- Comprehensive characterization of meteorological parameters and frequency of occurrence for icing conditions which aircraft will encounter
  - within current FAA aircraft icing certification envelope
  - conditions which fall outside envelope (e.g. - SLD)

- Supports NASA goal of enhanced safety and capacity





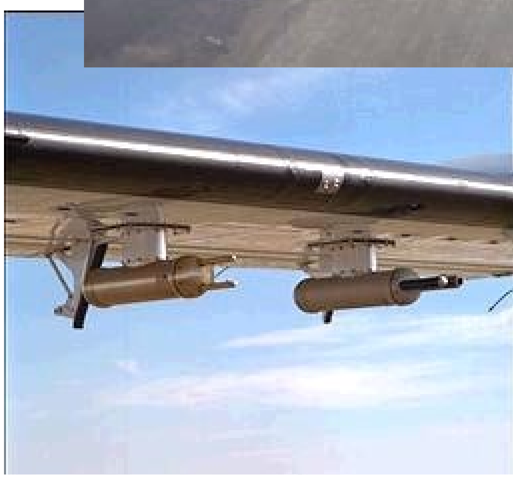
Objectives

- Quantify meteorological parameters associated with icing conditions *(water droplet size, concentration of water in icing cloud, temperature, etc)*

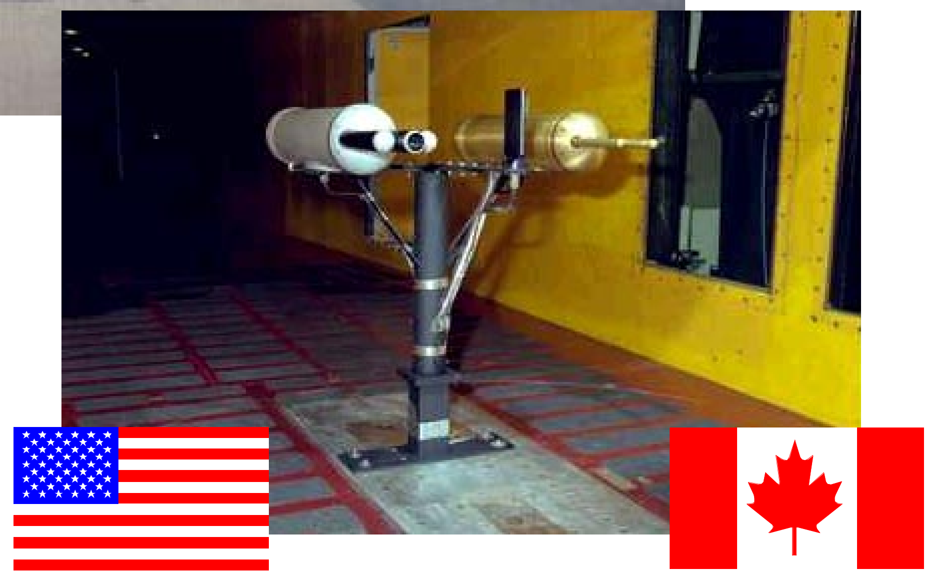
- Support the development of improved icing cloud instrumentation

Aerospace Operations Systems
Completion Of SLD Flight & Instrumentation Test

NASA Glenn Research Center Twin Otter Icing Research Aircraft



Icing Cloud Instrumentation mounted on the underside of the Twin Otter Wing



Joint NASA/AES Icing Cloud Instrumentation tests in the NASA Glenn Icing Research Tunnel

Aerospace Operations Systems
Technical Accomplishment

SLD Icing Program

POC: Dean Miller, Glenn
September 1999

Relevant Milestone: Complete flight tests and instrumentation comparison for the NASA/AES Joint Supercooled Large Droplet icing program. (AOS L1 Milestone, due Sept. 99)

Shown: Twin Otter and droplet particle measuring probes, both on the aircraft and in the tunnel.

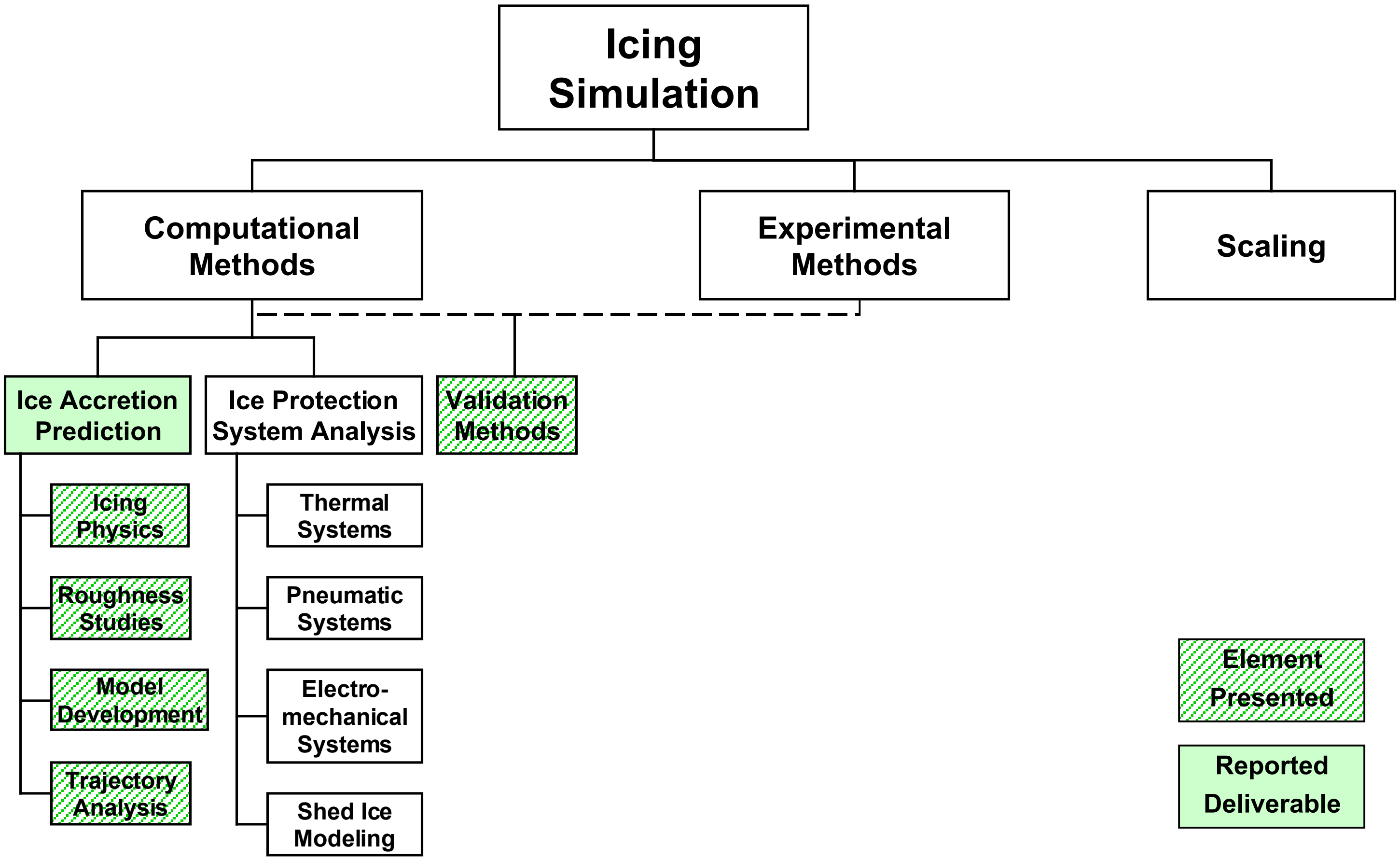
Accomplishment / Relation to Milestone and ETG: The flight tests for 97-98 and 98-99 winter icing season and the Icing Research Tunnel instrumentation comparison test (November 1998) are all completed. The data reduction and analysis is 70% complete, will be finished with analysis by FY00, 1st Qtr. Both activities are a cooperative effort with Atmospheric Environmental Services (AES), Canada to improve understanding of severe icing hazard - improve aviation safety.

- •NASA/AES Joint SLD program objectives: Improve SLD cloud data analysis, Identify new instrumentation for improved measurement capability, and Develop uniform analysis methods for atmospheric science community and for engineering standards development.
- •Final icing season flight testing completed March 1999 - SLD cloud characterization data sent to FAA Technical Center (Interagency Agreement) to develop new atmospheric icing engineering standard
- •National Center for Atmospheric Research (NCAR) meteorologist/researchers at GRC to support flight testing with weather (SLD) prediction capability. SLD data used to develop and validate weather forecast tools. (Space Act Agreement)
- •Instrumentation test in IRT with U.S. and international particle measuring probe developers (International Agreements) -develop controlled, uniform comparison database to determine cross-probe measurement attributes; assess improved sensing hardware

Future Plans: International Instrumentation Workshop to review results, develop requirements for improved SLD measurement capability, and develop uniform practices for measurement community

ETG: Reduce the aircraft accident rate by a factor of five within 10 years, and by a factor of 10 within 25 years

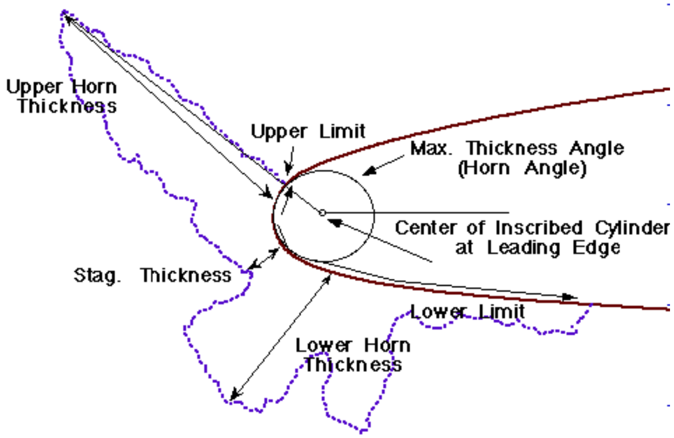
Icing Simulation Technology Elements

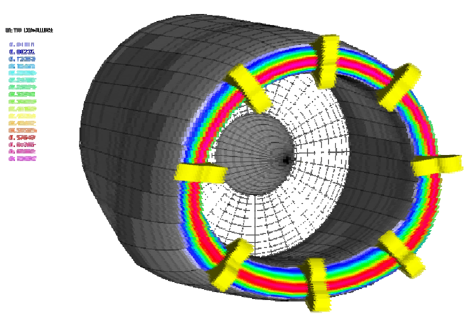


Goals & Objectives

Goal

- Develop validated computational and experimental tools for the simulation of aircraft encounters with atmospheric icing conditions
- Supports NASA goals of affordability and design tools.





Objectives

Develop and disseminate new knowledge in ice accretion physics.

Develop and modify simulation methods for ice accretion

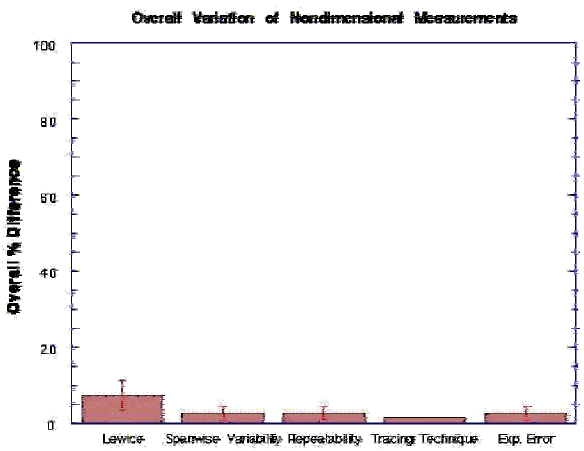
Apply computational simulation tools to:

- Enhance icing certification process
- Decrease costs of certification
- Reduce sensitivity of new aircraft and aircraft sub-systems to flight in icing conditions

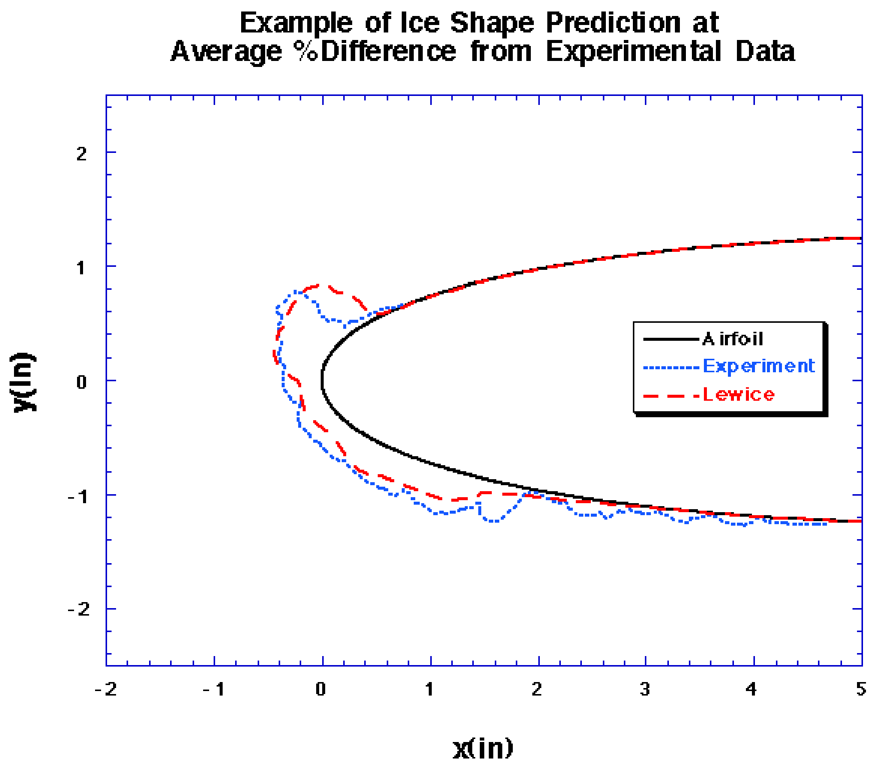
Aerospace Operations Systems

Validation and Release of LEWICE 2.0

Ice Shape Tracing; Providing Validation Data



Ice Shape Comparison Results Computational vs. Experimental



Aerospace Operations Systems
Technical Accomplishment

LEWICE 2.0 Release
POC: Mark Potapczuk, GRC
September 1999

Relevant Milestone: LEWICE 2.0 Release, (AOS Level II Milestone, 4th Quarter FY99)

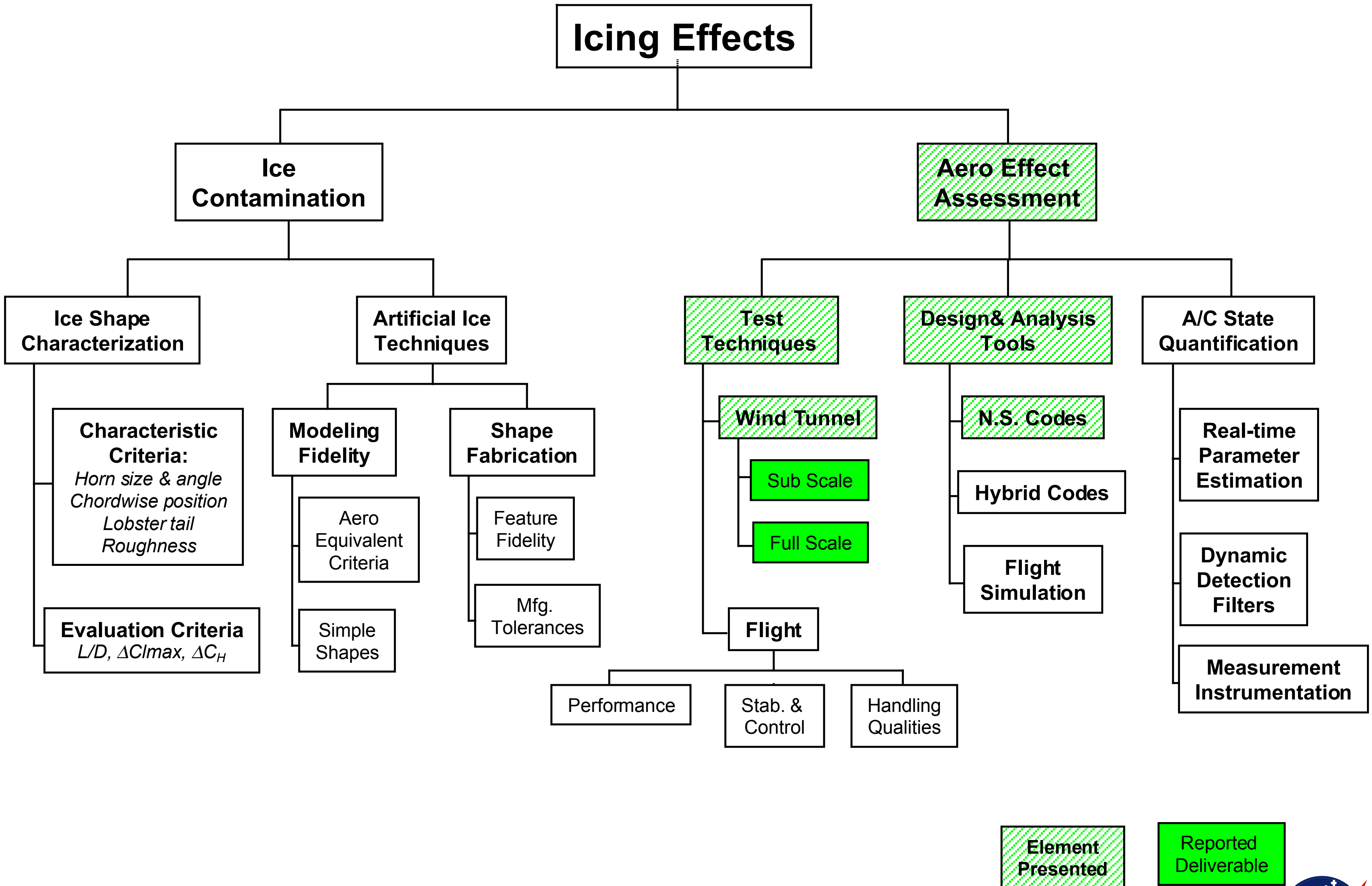
Shown: LEWICE 2.0 ice shape computation compared to measured ice shape from test in NASA Glenn Icing Research Tunnel (IRT). This result shows the typical level of agreement found in the current version of LEWICE. Also shown, is a comparison of LEWICE/experimental agreement compared to experimental repeatability.

Accomplishment / Relation to Milestone and ETG:
The LEWICE Workshop was held in September and the software was released to users at that time. LEWICE is the first ice accretion computational tool to have been validated by comparison with such a large number of experimental data points. Delivery of this software will assist manufacturers and OEMs in design and certification.

Future Plans: Thermal ice protection system (IPS) analysis capability will be added to LEWICE in upcoming releases. The IPS software modules will be subjected to the same development and validation procedures applied to this release of LEWICE.

ETG: Provide next generation design tools and experimental aircraft to increase design confidence, and cut the development cycle time for aircraft in half.

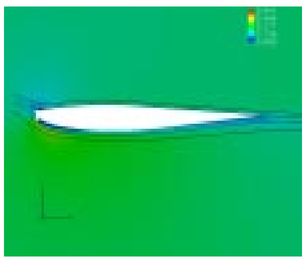
Icing Effects Technology Elements

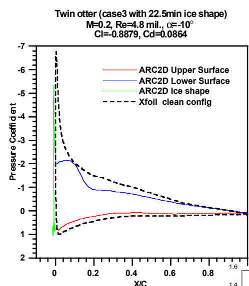


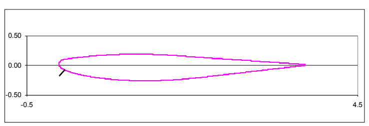
Goals & Objectives

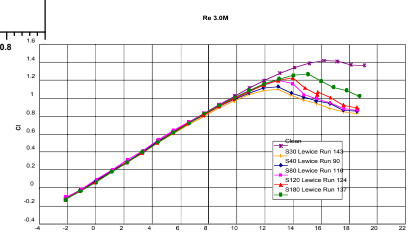
Goals

- Develop technologies to assess the impact of ice on aircraft performance, stability, controllability and handling qualities
- Support NASA goals of enhanced aviation safety and design tools



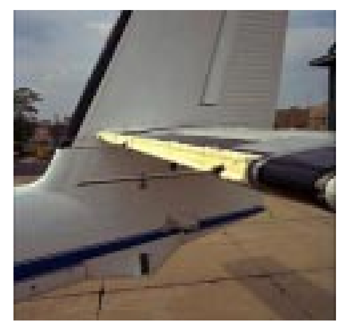






Objective

- Develop proven methods for utilizing analytical tools, wind tunnels, and flight simulation and aircraft to assess aero effects due to icing

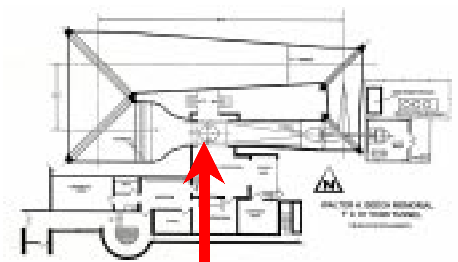


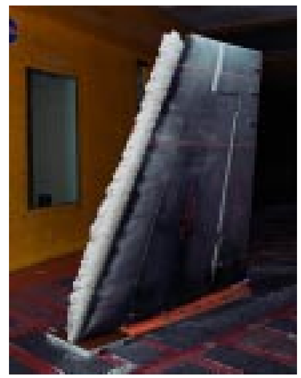
Aerospace Operations Systems

Tailplane Icing Program, Phase II

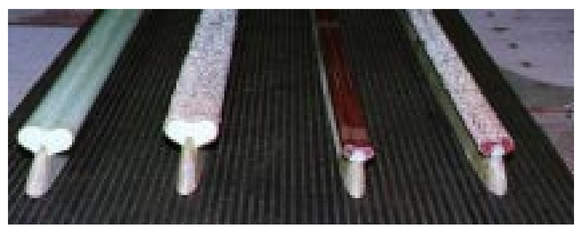
Aerospace Operations Systems Base R&T Program

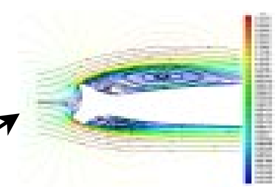
Sub-scale Business Jet Empennage and Complete Aircraft model testing at WSU 7'x10' Low Speed Wind Tunnel

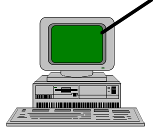




Ice shapes from IRT and LEWICE

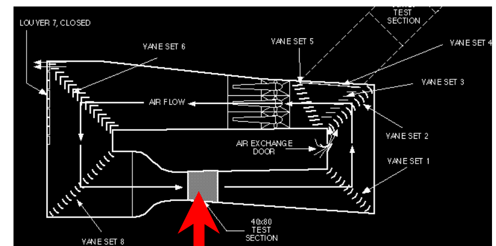






Numerical Tools for Test setup and Verification

Full-scale Business Jet Empennage test at NASA-ARC National Full-Scale Aerodynamics Complex



AOS

J. V. Lebacqz

Aerospace Operations Systems
Technical Accomplishment

Tailplane Icing Program- Phase II
POC: Tom Ratvasky, GRC
Full-Scale Test Completed: August 1999

Relevant Milestone: Complete TIP full-scale testing and investigate relationship between full- and sub-scale model test results. (AOS LIII Milestone, 4th Quarter 1999)

Shown: Business Jet Empennage (BJE) 25%-scale model in WSU 7x10 tunnel and full-scale BJE in NASA 40x80 tunnel. Truncated full-scale horizontal tail in NASA IRT and artificial ice shapes made using LEWICE results. ARC2D results used pretest for selecting pressure tap locations.

Accomplishment / Relation to Milestone and ETO: Comprehensive data base of tailplane aeroperformance with various levels of artificial ice contamination covering a wide range of Reynolds numbers. Preliminary results indicate excellent agreement between 25%- and full-scale iced aero-performance. Techniques for scaling ice shape size were investigated and found successful for the scales examined. When validated, these techniques will reduce the time and cost for icing certification.

Future Plans: Complete analysis of full-scale data and compared to 25%-scale results. Conduct wind tunnel test of a 15%-scale, complete aircraft model in FY00 to expand scaling investigation and include effects of flaps and fuselage. Results to be compiled and available to aerospace industry by 3rd Qtr FY02.

ETG: Reduce the aircraft accident rate by a factor of five within 10 years, and a factor of 10 within 20 years. And provide next-generation design tools to increase design confidence and cut the development cycle time for an aircraft in half.

Issues

- Loss of Icing Research Aircraft - Twin Otter
  - Efforts to retain aircraft permanently have still not been successful
  - Loss would impact all elements of AI project (Remote Sensing, SLD, TIP, AIRS, SIS, Pilot Simulator) - delays and or cancellations
- Permanent Level II Icing Manager needs to be assigned
  - Rounds out ‘Icing Management Team’ (IRT Facility Manager, Icing Research Branch Chief, and AI Project Manager)
  - Planned to be in place by end of the calendar year
- Workforce shortfall in Icing Research Branch continues to be a concern to the project; struggling to meet commitments with current and projected civil servant staff
  - Additional civil servant staff for Icing Research Branch has become higher priority for R&T Directorate

Aviation Weather Information

Frank Jones
Langley Research Center

Aviation Weather Information (AWIN)

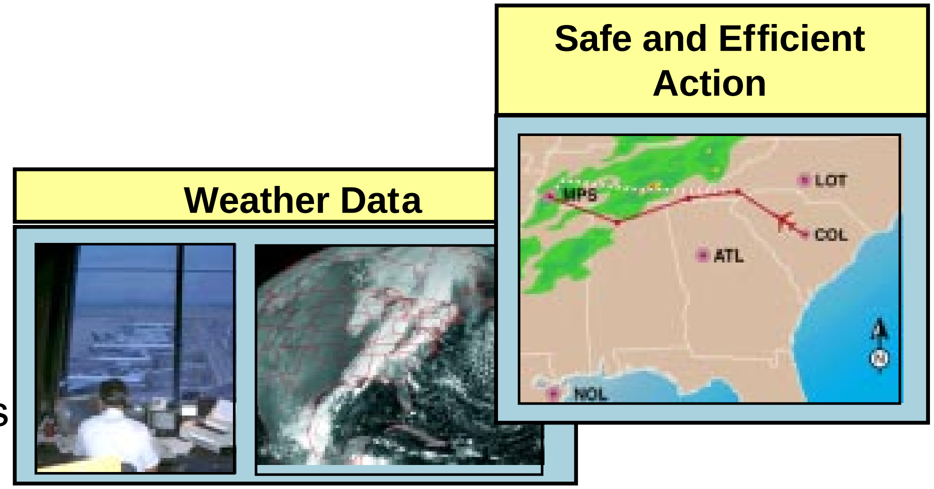
Goal

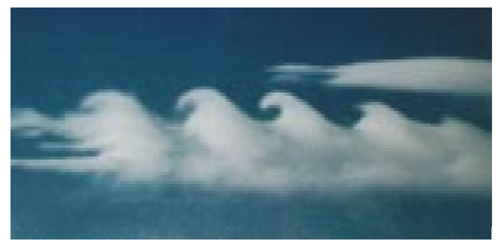
•Eliminate atmospheric hazards as a safety concern for aircraft operations in all weather conditions

Objective

•To reduce weather related accidents by enabling the development and implementation of technologies, products and systems for communicating and displaying timely weather information to airborne and groundbase users

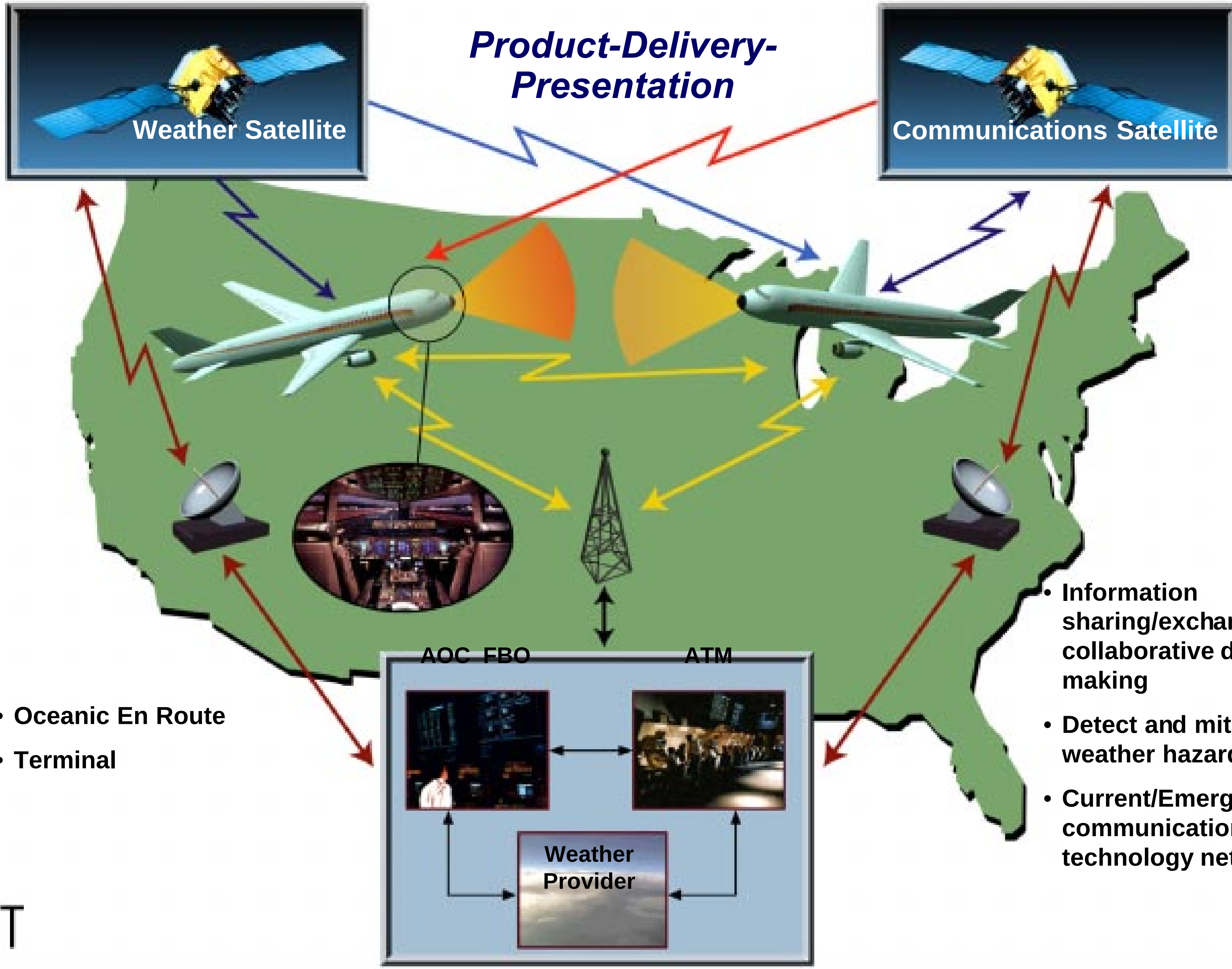
•Develop technologies for and facilitate operational implementation of airborne clear air turbulence mitigation system





Level 1 Milestone	Output Metric	Outcome
Define and evaluate operational concepts for all-weather turbulence detection systems (4QFY99)	Quality and breadth of flight test database	Reduced CAT accidents and incidents
Evaluate and select Aviation Weather Information (AWIN) concepts (4QFY99)	Focus and quality of specification for system design	Reduced weather-related accidents

Project Approach



- Oceanic En Route
- Terminal

- Information sharing/exchange for collaborative decision making
- Detect and mitigate weather hazards
- Current/Emerging communications technology network

Aerospace Operations Systems Base R&T Program

Major Technology Elements

Aviation Weather Inforamation Research

WBS

AWIN	Communication	Turbulence
- Enhanced Weather Product - Operator Support - Cooperative Research Agreements	- Communications Systems and Technology Requirements - Communications Systems and Technology Experiments and Demo - Communication Technology and Standards Development	- Turbulence Characterization - Detection - Nowcasting/Forecasting - Mitigation and Control

Objectives

AWIN
- **Develop technologies and methods to provide sufficiently accurate, timely and intuitive information to pilots, dispatchers, and air traffic controllers**
- **Develop Needed Weather Products and Sensing Capabilities**
- **Develop Enhanced Weather Presentations and Decision Aids**

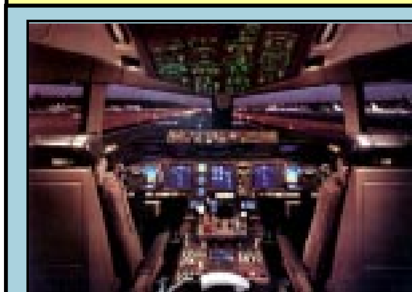
Communication
- **Develop advanced communication systems to enable the efficient and timely dissemination of high quality, accurate aviation weather information**
- **Develop advanced communications and information technologies**

Turbulence
- **Develop technologies that will enable reliable and timely turbulence detection & Mitigation**
- **Develop technologies to enable reliable forecasting and nowcasting for strategic turbulence avoidance**

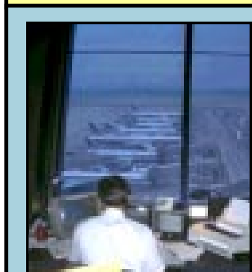
AWIN Approach

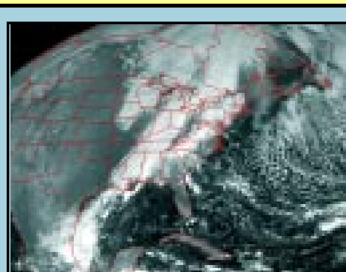
Aerospace Operations Systems Base R&T Program

Operator Support

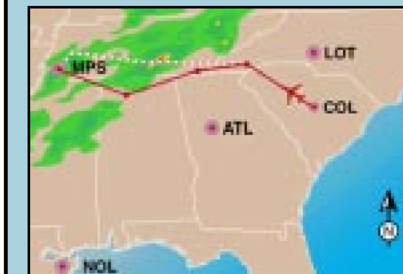


Enhanced Weather Products





Safe and Efficient Action



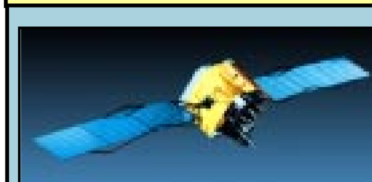
Decision

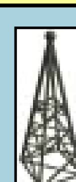
Information Presentation

Processor

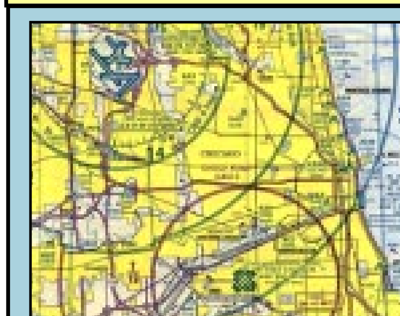
Database

Data Communications/Link





Terrain Obstacles Air Space Traffic



Aircraft Capabilities

- Provide the Flight Deck ATM & AOC with Higher Fidelity, More Timely Intuitive Graphical Information
- For all classes of Aircraft
- Requirements/data driven approach

Cooperative Research Efforts

- National Airline / Transport and World-Wide Weather Information Systems
  - **Boeing** — **Aviation Weather Information (AWIN)**
  - **Honeywell** — **Weather Information Network (WINN)**

- National General Aviation Weather Information Systems
  - **ARNAV** — **Weather Hazard Information System: Reducing GA Fatal Weather-Related Accidents**
  - **NavRadio** — **GA-Oriented VHF DataLink (VDL) Mode 2-Based Weather and Flight Information Services (FIS) Broadcast, Reception, and Display System**

- Topical Category
  - **Honeywell** — **Weather Avoidance Using Route Optimization as a Decision Aid**
  - **NavRadio** — **General Aviation Oriented Electronic Pilot Report (EPIREP) Generation and Datalink System**
  - **Rockwell** — **Aviation Weather Awareness and Reporting Enhancements (AWARE)**
  - **Rockwell** — **Enhanced On-Board Weather Information System**
  - **NCAR** — **A Demonstration of an End-to-end Oceanic Weather Hazard Information Dissemination System**

Turbulence Element Approach

Aerospace Operations Systems Base R&T Program

Sensor Performance Assessment

•Sensor Development

•Algorithm Development

• Demonstration & Verification

Turbulence Characterization

Turbulence Modeling

•Requirements Definition

•Severe Events Database

•Hazard Metric Development

•Hazard metric development

Detection

Forecasting/Nowcasting

Turbulent Tolerant Flt. Control Algorithm

•Demonstration & Verification

Mitigation

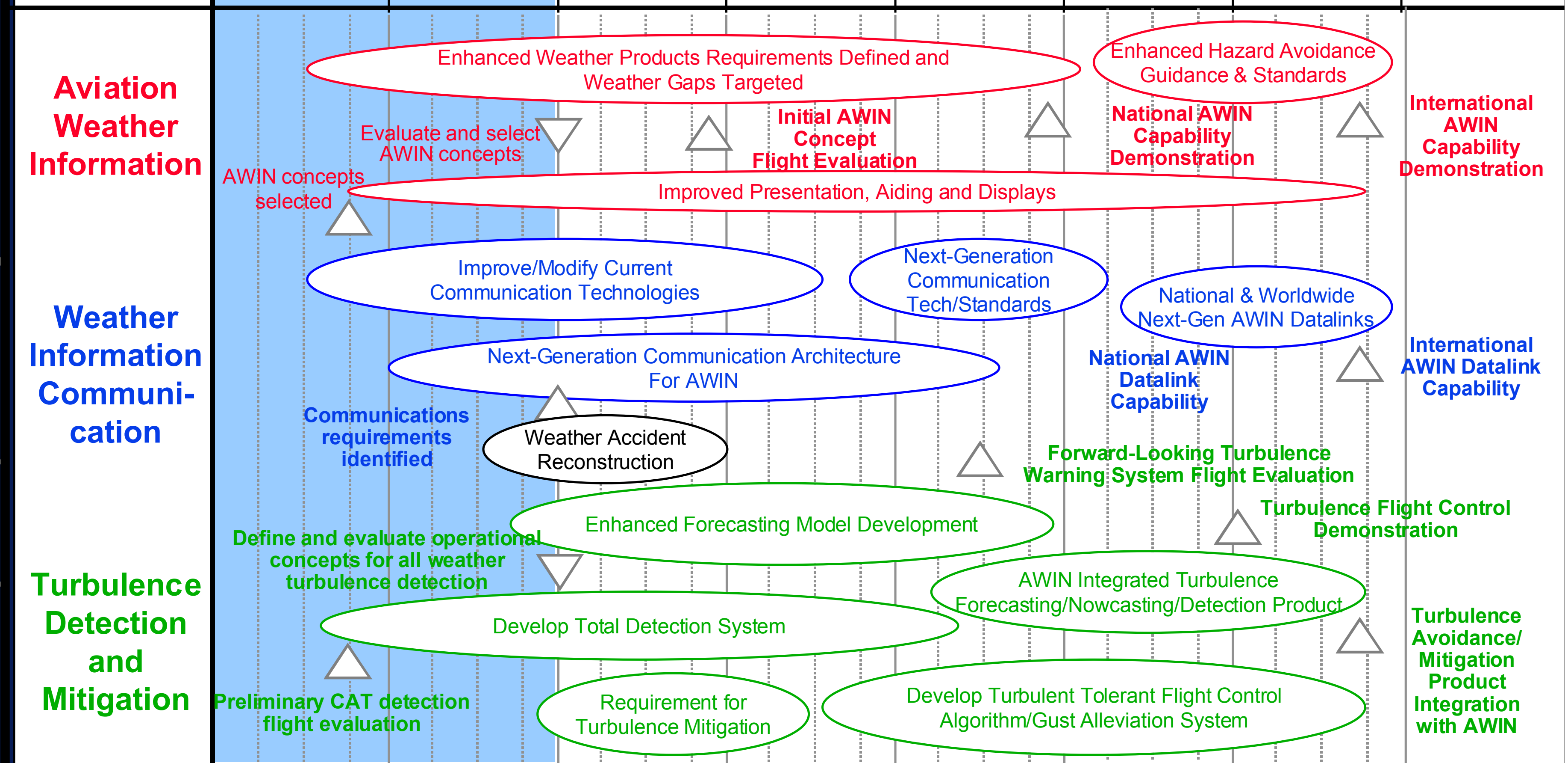
Strategic Route Management

•Assessment of Existing Turbulence Products

Aerospace Operations Systems Base R&T Program

Aviation Weather Information Research Roadmap

	AOS-AWIN		AvSP					'00 - '04 Totals
FY	1998	1999	2000	2001	2002	2003	2004	
NASA $(M)	5.7	10.2	11.3	12.1	11.7	14.3	14.8	64.2



▽ AOS Program Milestone △ Project Milestone

AOS

J. V. Lebacqz

Aviation Weather Information Research
Technical Accomplishment

Weather Information Distribution/Presentation

POC: Frank Jones (548-81)

September 1999

Relevant Milestone: Evaluate and select Aviation Weather Information (AWIN) concepts

Shown: The AWIN prototype systems. This represents a step toward a commercially viable AWIN system that will enhance pilot situation awareness of weather phenomenon along active and proposed flight paths for both General Aviation and Transport category aircraft. Pilot enhanced situational awareness will decrease the accident rate where weather is a contributing factor, while increasing efficiency due to better reroute decisions.

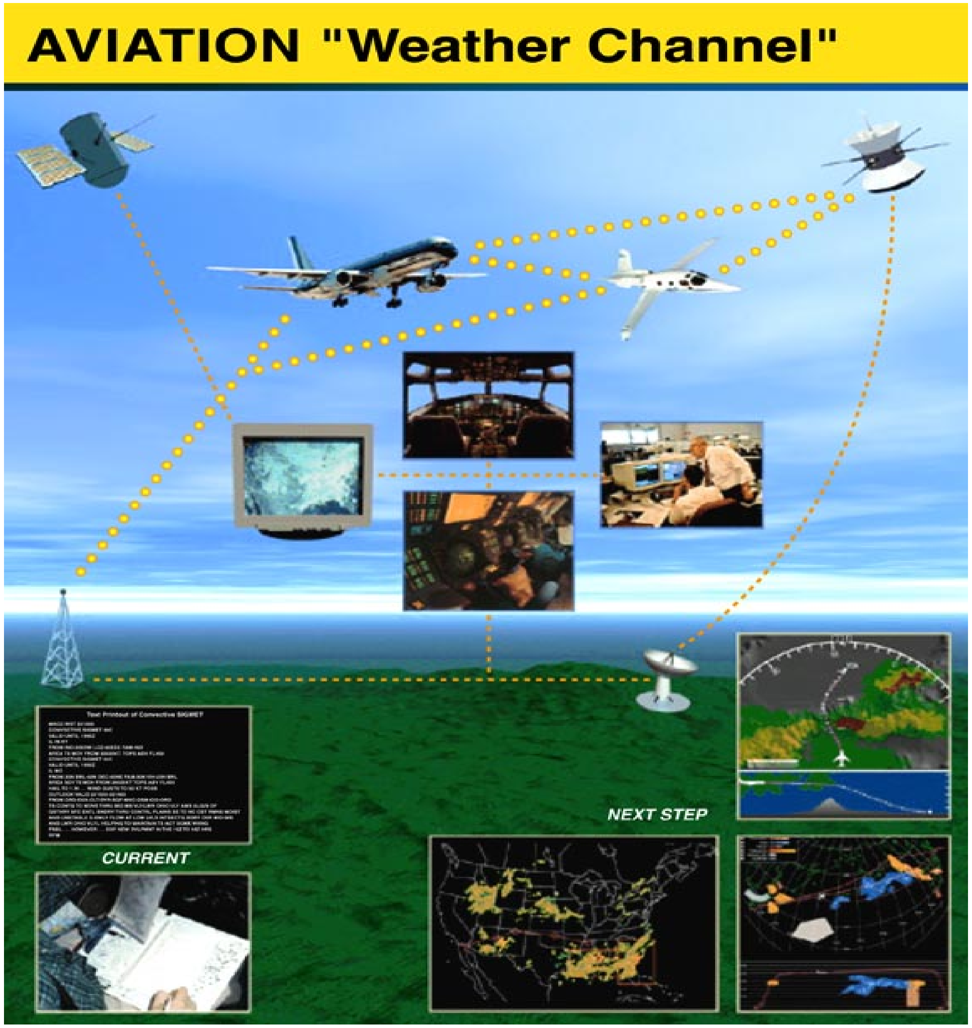
Accomplishment / Relation to Milestone and ETG: Multiple AWIN systems have been developed, evaluated and demonstrated to provide graphical weather information in the flight deck for national and worldwide airspace. These systems were demonstrated using various packaged weather products that were delivered to the flight deck using satcom broadcast, cellular phone and ground based 2 way broadcast infrastructure. The weather products that were evaluated included turbulence, weather radar (US only) satellite, convective detection(experimental) METARs and SIGMETs. Rapid prototyping led to flight evaluations on a Cessna Citation, USAF C-135(Speckled Trout), Fed-x Cessna Caravan and numerous general aviation aircraft. Demonstration of Public/Private partnerships to accomplish a common research goals.

Future Plans: The next phase includes installation of a WINN system in an airline transport aircraft flying normal revenue operations . Additional weather products for strategic and tactical weather information will be evaluated. Flight evaluation of decision aids for route optimizing and weather hazard alerts.

ETG: Reduce the aircraft accident rate by a factor of five within 10 years, and by a factor of 10 within 25 years.

Aviation Weather Information Research

AWIN Distribution and Presentation

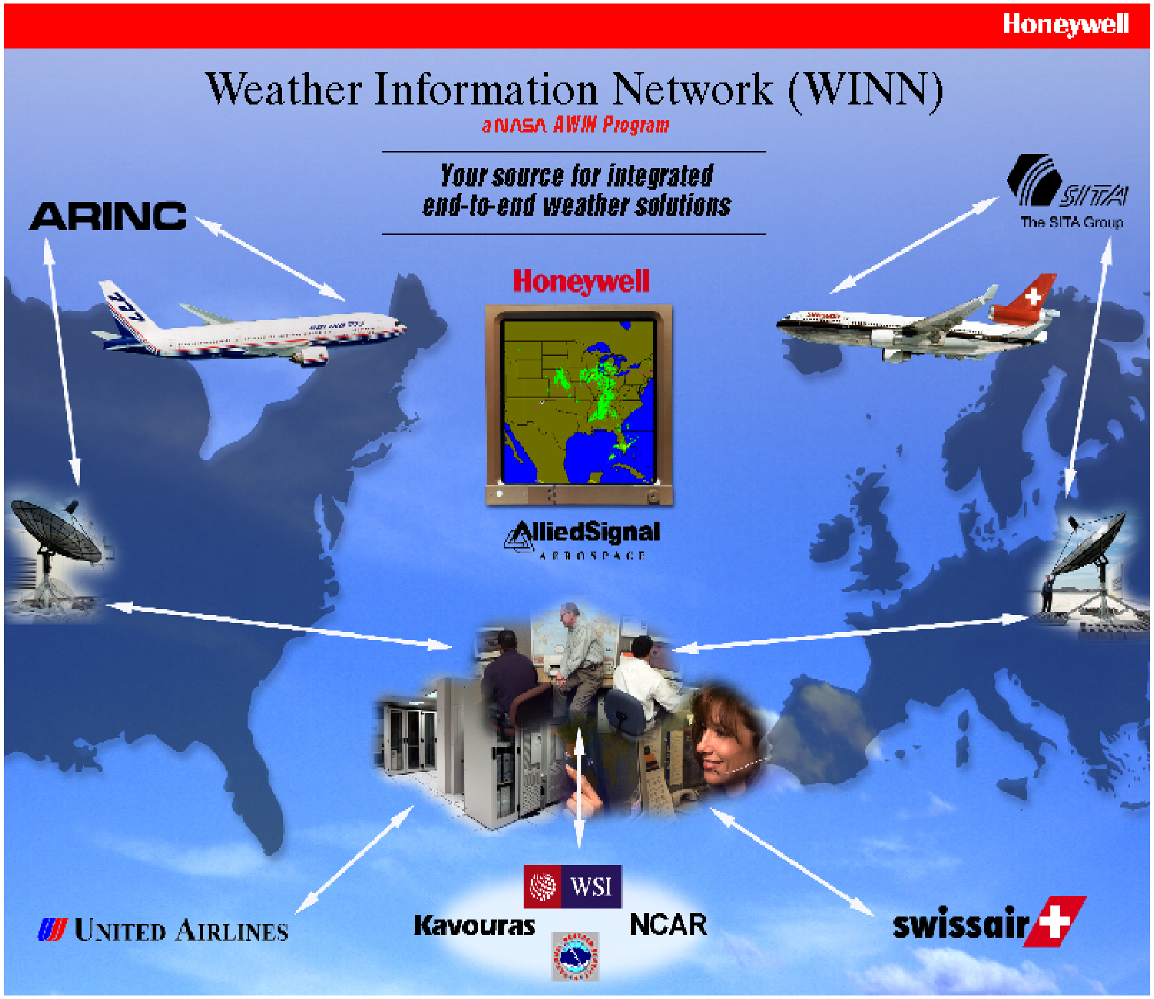



Multi-Function Display Installation

J. V. Lebacqz

Aviation Weather Information (AWIN)

Air Carrier Cockpit Display of Weather Information



Accomplishments:

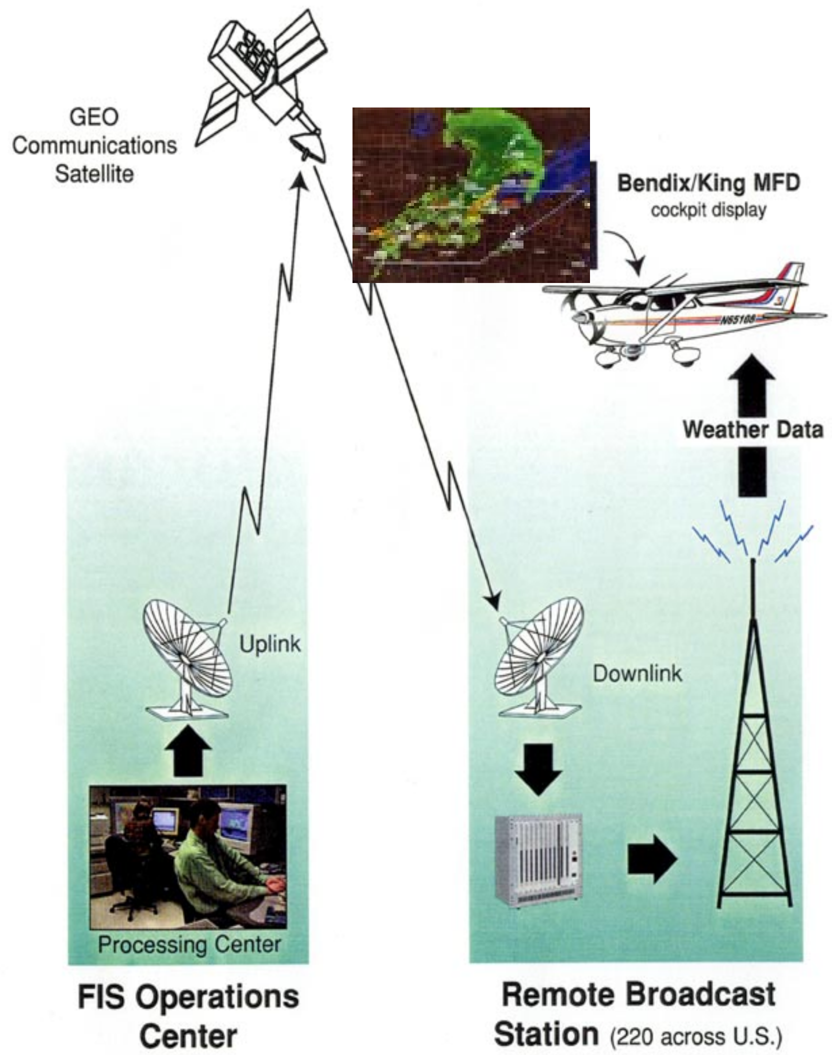
- Established data center
- Installed and tested multiple datalinks
- Developed pilot interface
- Installed and tested multiple data links between ground and aircraft
- Flight demonstrated complete end-to-end system on a Cessna Citation
- Multiple products delivered to the flight deck:
  - Turbulence Detection
  - Weather Radar (US Only)
  - Satellite
  - Convective Forecast
  - Convective Detection
  - METARs

Future Plans:

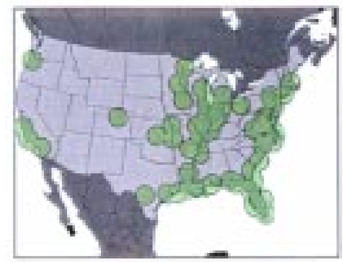
- Installation of a WINN system in an airline transport aircraft flying normal revenue operations

Aviation Weather Information (AWIN)

General Aviation Cockpit Display of Weather Information



Planned Coverage (5000' AGL)



Initial operation capability Sun 'n Fun 2000

One year capability Oshkosh AirVenture 2000

Full operation capability Oshkosh AirVenture 2002

Accomplishment:

- Uplink high resolution weather radar using compact low-cost ground stations
- Open standard digital protocol (VDL Mode 2)
- Selected by FAA to implement/provide national weather in the cockpit capability to general aviation beginning early '00

Future Plans:

- System will be expanded to 20 ground stations
- Three geographically diverse areas
- Tested in "real-world"conditions using 32 participating aircraft

Aviation Weather Information Research

Turbulence - Airborne Sensor Assessment

Turbulence

POC: Frank Jones

Relevant Milestone: Define and evaluate operational concepts for all-weather turbulence detection systems

Shown: There are three sensor technologies having the needed detection capability and range. They are Radar, Lidar and Radiometry. The figure graphically describes their complementary capabilities, and technical readiness. This report explores the concept of a sensor suite, which is operable over a wide range of conditions, and has a lower probability of false alarm than any of the individual sensors.

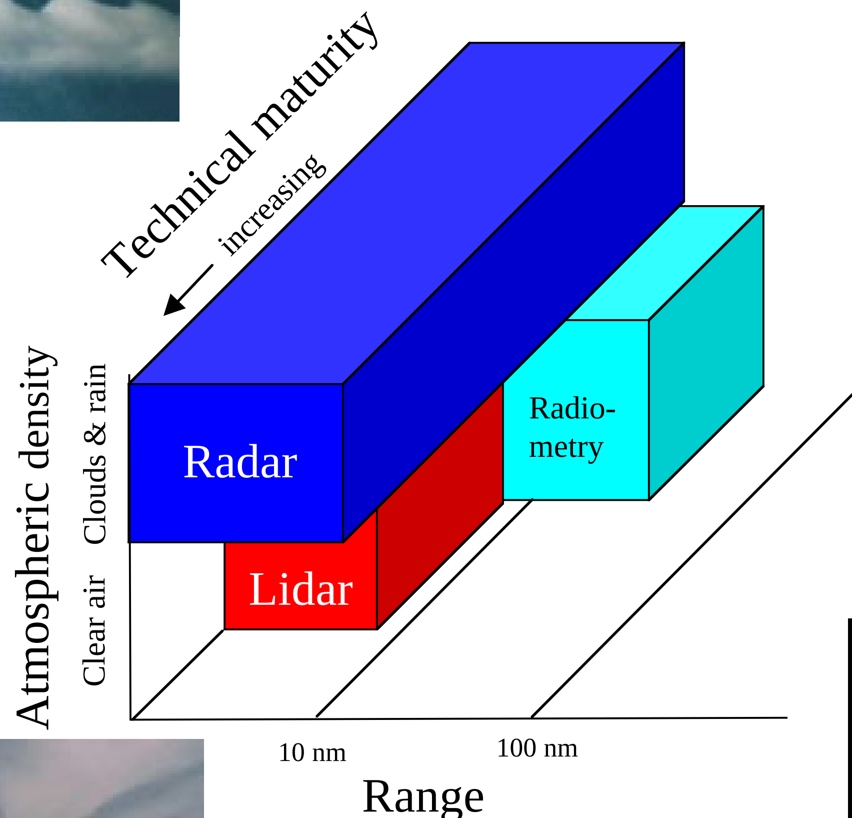
Accomplishment / Relation to Milestone and ETO: The report documents the available airborne turbulence sensors, lists their capabilities and limitations, and points out areas that must be developed in order to field an accurate, reliable suite of turbulence sensors. This supports the milestone Demonstrating a Forward Looking Turbulence Sensor by starting the process of selecting and/or combining the sensing technologies. Completed preliminary flight evaluations of enhanced radar and a Lidar systems. Enhanced radar systems are being pursued by industry for turbulence detection when limited moisture is present. Lidar system have demonstrated (limited flight data) an ability to detect clear air turbulence.

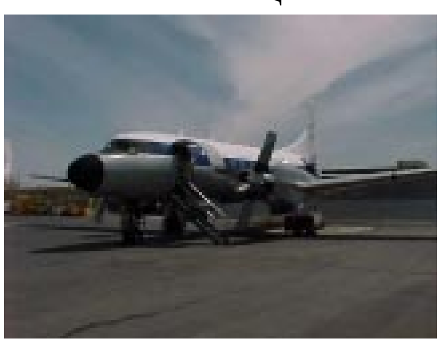
Future Plans: The report documents that the sensors currently under development are the most appropriate for airborne turbulence sensing. A third technology, radiometry, may provide an attractive, inexpensive, complementary capability to the sensor suite.

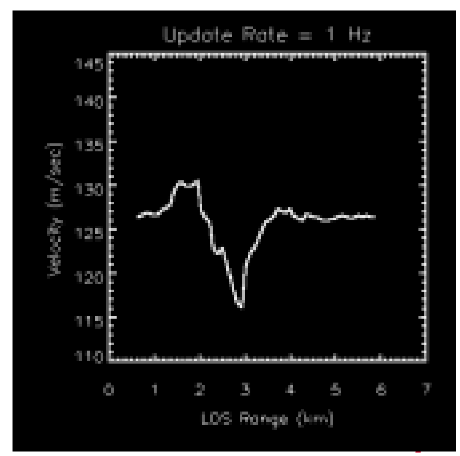
ETG: Reduce the aircraft accident rate by a factor of five within 10 years, and by a factor of 10 within 25 years.

Turbulence

Airborne Turbulence Sensor Assessment





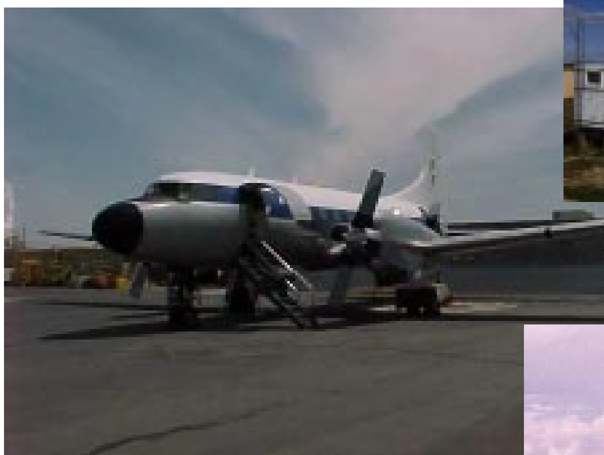


Turbulence Element Technical Highlight

Convective Turbulence Data-Collection Field Deployment

Aerospace Operations Systems Base R&T Program

Convair 580 Aircraft



CHILL Doppler Radar

T-28 Armored Aircraft

Sabreliner Aircraft

Pawnee Doppler Radar

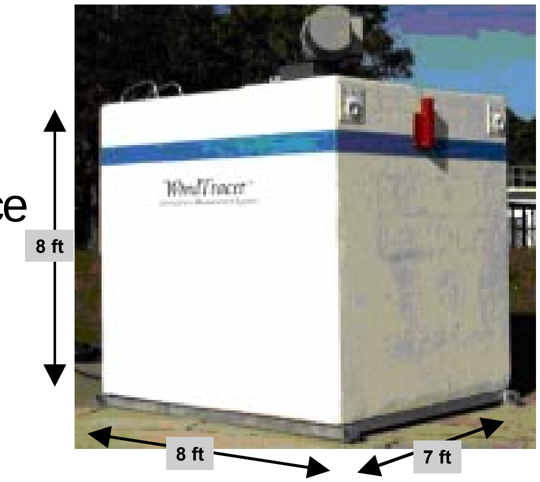
- **The Convair 580 and Sabreliner aircraft with forward-looking, X-band radars will fly in-trail of the T-28 to assist in characterizing those radars for turbulence detection.**
- **T-28 will fly through convective turbulence, including thunderstorms, measuring actual turbulence levels.**
- **Ground-based Doppler radar will assist in characterizing atmospheric phenomena.**
- **Flights will occur in the vicinity of Ft. Collins, CO.**
- **Agreements and test plans are in place to initiate flights on June 2 and complete no later than July 1, 1999.**

AOS

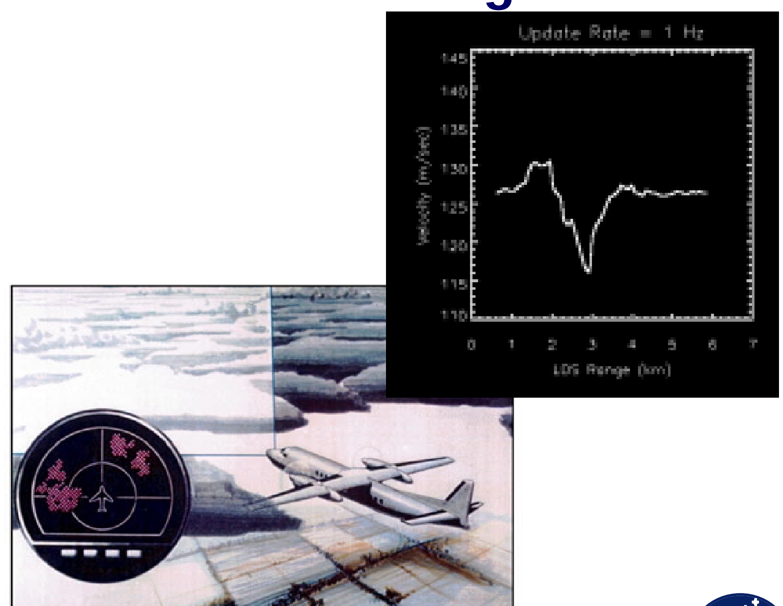
J. V. Lebacqz

Turbulence Element Technical Highlight

- **Brought Lidar sensor to Juneau for wind field measurements**
  - For strong wind 'events', generated database for characterizing severe low altitude windshear and turbulence (FAA)
  - Mapped terrain-induced windshear and turbulence (TIWT) flows in and around airport (FAA)
  - Generated validated data sets to support development of lidar turbulence and windshear detection algorithms (NASA)



- **Flight Evaluation of a Lidar On-Board Forward-Looking Turbulence Detection system**
  - Detected light to moderate turbulence at ranges between 3 and 6 miles ahead of aircraft
  - Penetrated turbulence to verify
  - Operated 15 hours in a variety of aerosol conditions and atmospheric moisture at altitudes from ground to 25k ft.



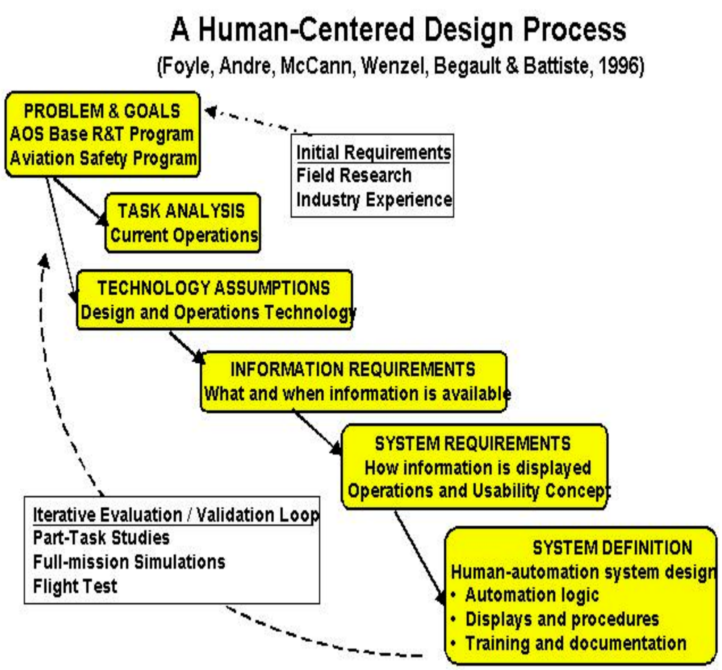
Human-Automation Integration Research

Dr. Michael G. Shafto
Ames Research Center

Goals and Objectives

Human-Automation Integration Research Goal

Enhance capability, improve safety, and reduce costs of automated aerospace operations.



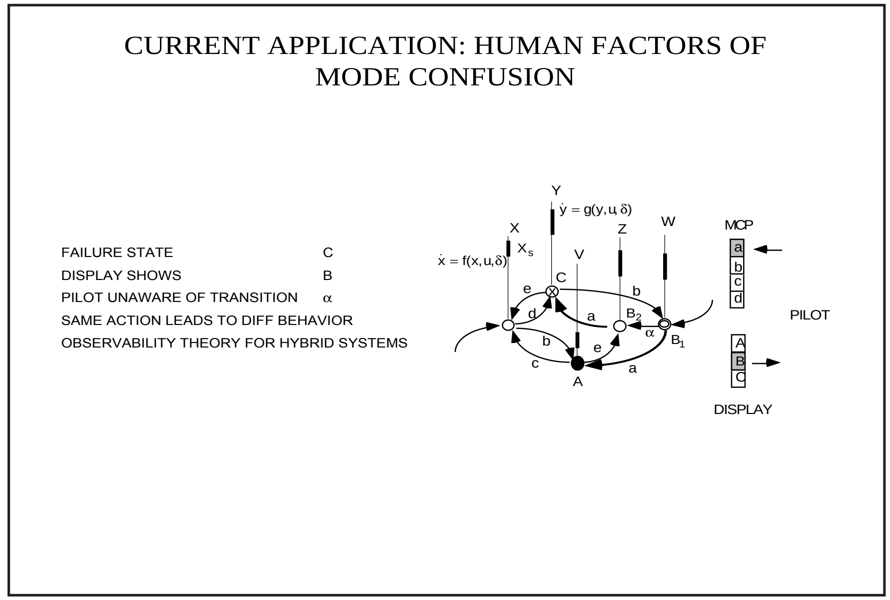
Objectives

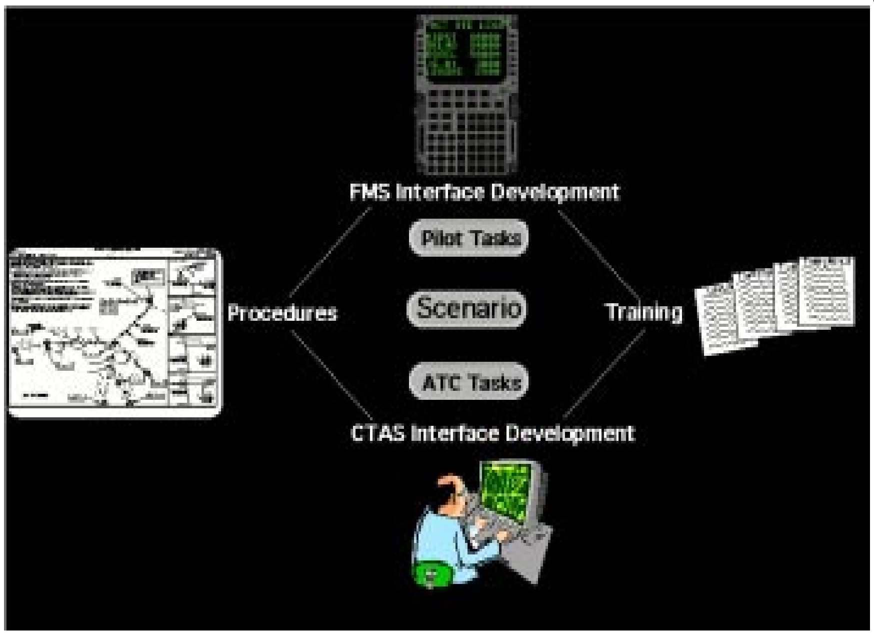
With U.S. industry and federal agencies:

- Eliminate mode error as a cause of accidents
- Demonstrate cost-effective training for automation
- Demonstrate human-centered design of displays and procedures
- Develop predictive task analysis methods
- Support FAA certification efforts

Progress

- Recognition of the problem (1980-85)
- Documentation of the problem (1985-)
- Weak solutions proposed (1990-)
- Single-point technologies (1985-)
- Hybrid control theory (1970-)
- Large-scale analyses (1990-)
- Design-relevant demos (1995-)
- Certification issues addressed (1995-)

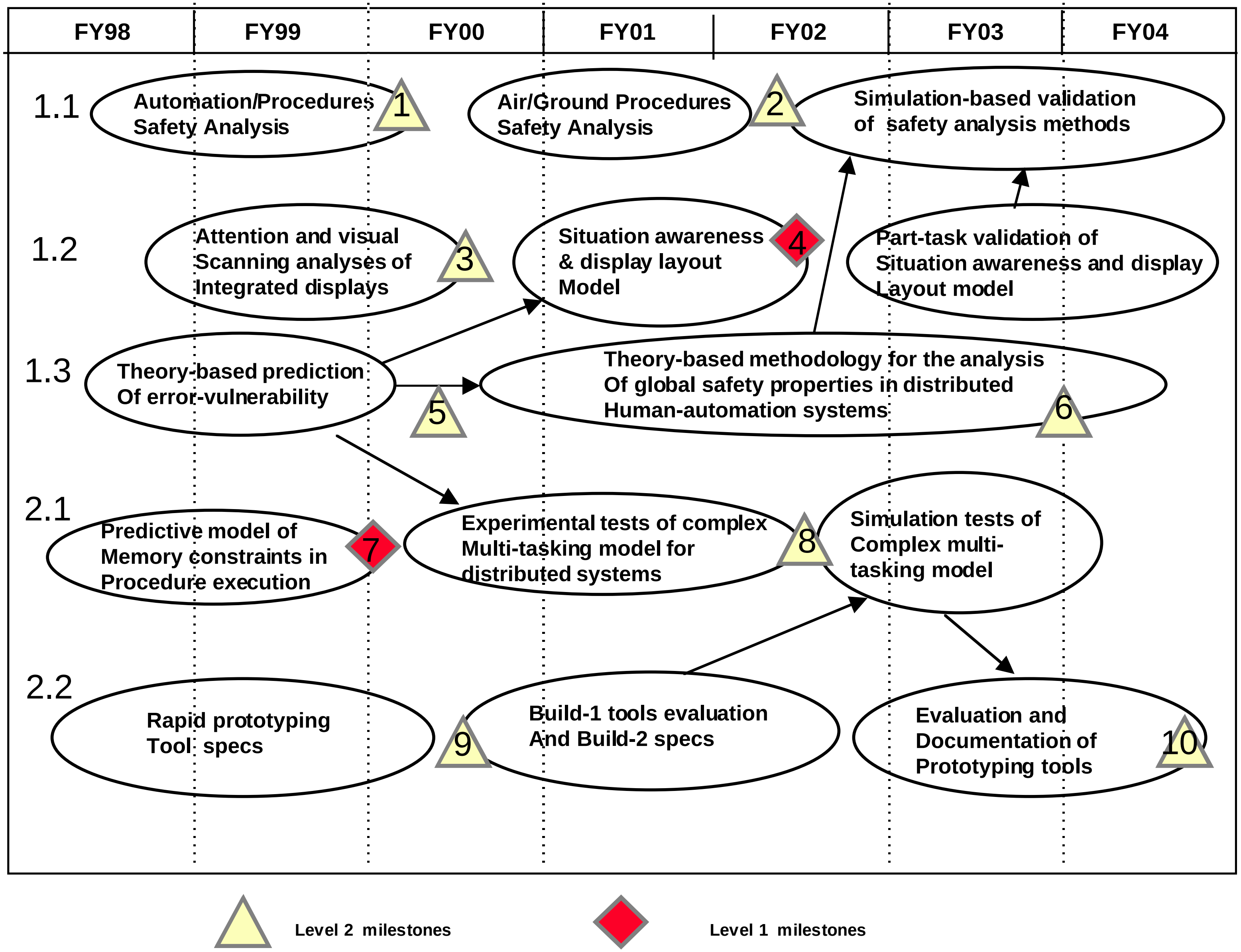




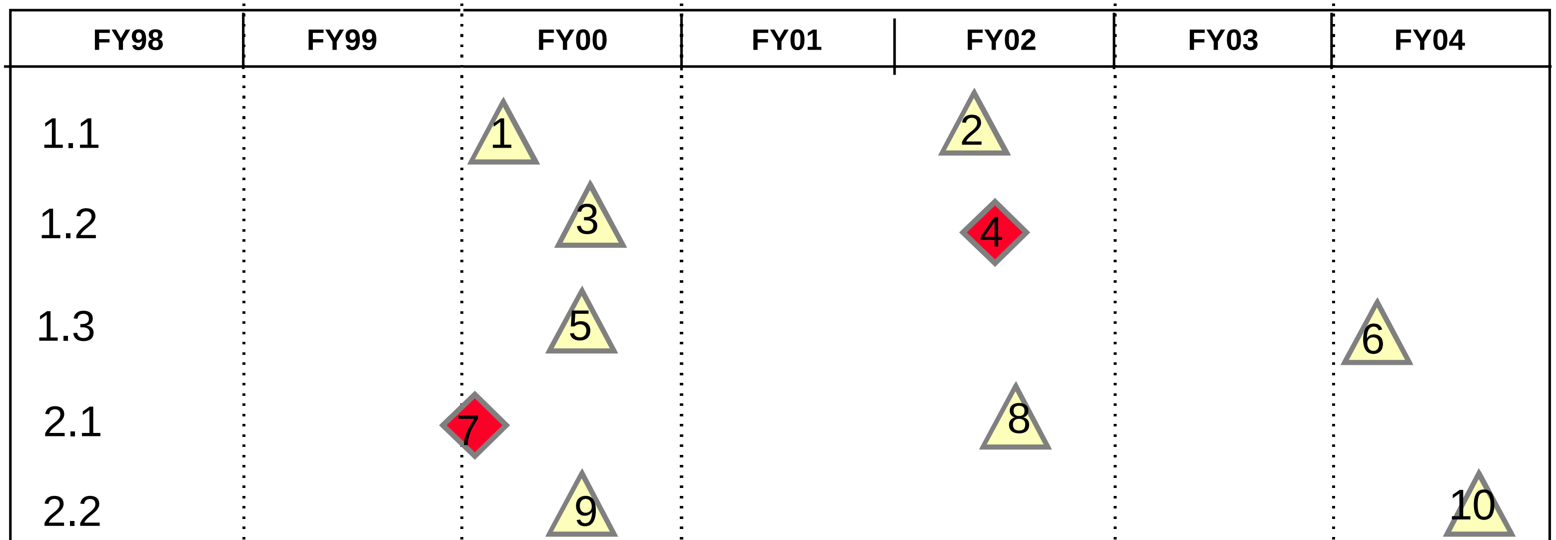
Challenges

- Integrated design synthesis
- Distributed systems
- Scale and heterogeneity
- Tool usability
- Rapid prototyping
- Cognitive modeling
- Display content modeling
- Validation

Roadmap & Milestones



Milestone Key

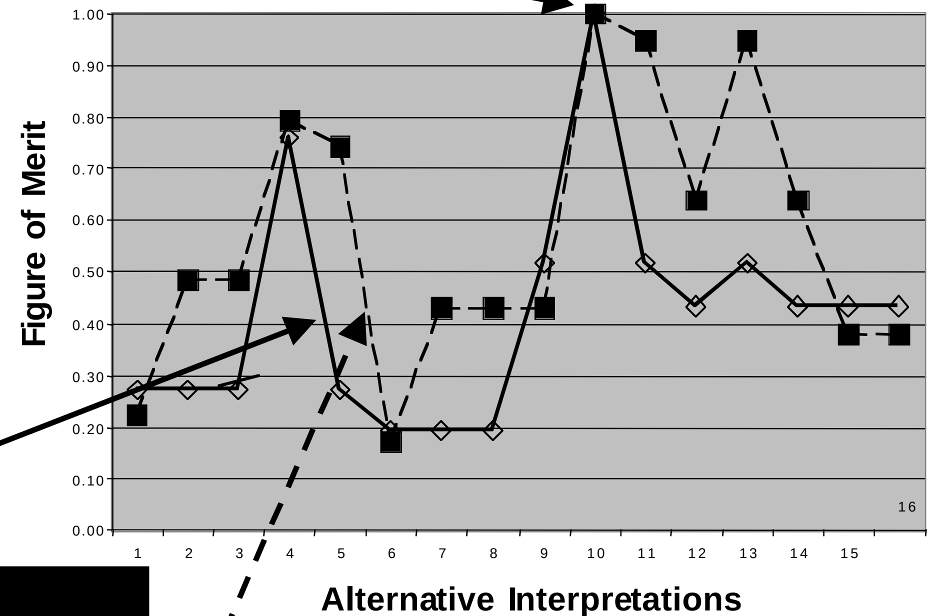


1. Automation/procedures safety analysis replication and extension
2. Advanced air-ground safety analysis validated in simulation
3. Phase 2 model-based situation-awareness and display-layout analysis
4. Validated display guidelines based on information requirements model
5. Theory-based methodology for predicting error-vulnerability in design
6. Demo. of theory-based predictive safety analysis for distributed systems
7. Predictive model of memory constraints in procedure execution
8. Experimental tests of error-predictions by multitasking model
9. Build-1 rapid prototyping tools complete and documented
10. Final evaluation and documentation of prototyping tools completed

Level 2 milestones **Level 1 milestones**

Comparison of FMA's

Correct Interpretation



The aircraft is level at 23,000 ft, the clearance altitude, in VNAV. The crew is waiting for a clearance to 33,000 ft, their cruse altitude.

Experimental FMA

300 | NAV1 | CLB INT LEVEL 23000

Control FMA

300 THRUST | NAV1 | CLB THRUST 23000

Observe that there are two alternative interpretations of the Control FMA that are very similar to the correct interpretation.

Comprehension-Based Analysis of Autoflight Interfaces

Dr. Michael G. Shafto

September 1999

Relevant Milestone: Develop model of human memory constraints in reactive planning and procedure execution (Level 1 Milestone, due Q4, FY99).

Shown: Model-based analysis shows reduced error-vulnerability for redesigned FMA.

Accomplishment/Relationship to Milestone and ETG:

The method is able to show whether pilots can rapidly make the correct inferences about the avionics and current state of the mission. The method also predicts patterns of confusion errors.

The current version of the comprehension-based model simulates a pilot who is attempting to infer the underlying state of the avionics, such as the mode of the autopilot, by rapidly scanning the primary flight display (PFD) and the flight mode annunciator (FMA). The model incorporates a detailed representation of the displays, the knowledge necessary in memory to interpret the displays, and the possible alternative interpretations of the displays. The model computes a figure of merit for each possible interpretation of a configuration of the displays. The objective of the evaluation process is to show that correct interpretation receives the highest figure of merit and that no alternative interpretation receives an evaluation that is close to the highest value.

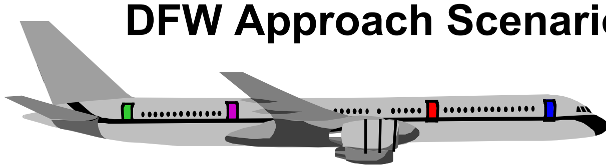
The method has been used to evaluate several prototype avionics displays that have been developed at Ames, by performing simulated comparison of these experimental designs with standard cockpit displays. The method has been also extended to the evaluation of vertical situation displays.

Plans: Possible extensions of the methodology to the evaluation of air traffic control displays are being explored. With U.S. air carriers and avionics companies, new automation displays and related intelligent training programs for autopilot and for vertical flight-path management are being evaluated.

ETG: Reduce the aircraft accident rate by a factor of five within 10 years, and by a factor of 10 within 25 years.

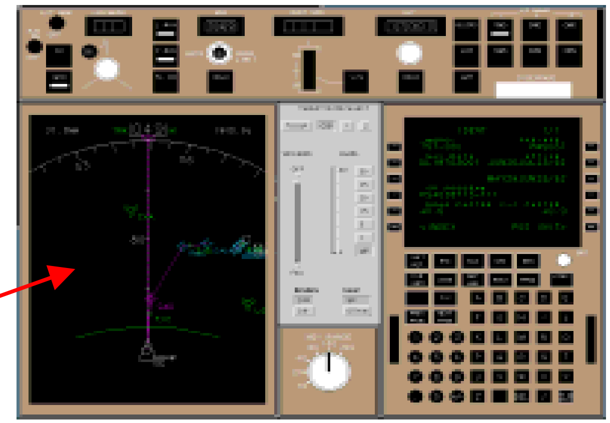
Human Memory Constraints in Procedure Execution: Predicting Error Vulnerability

DFW Approach Scenario



Flight Control Automation

2. Speed controlled via MCP.

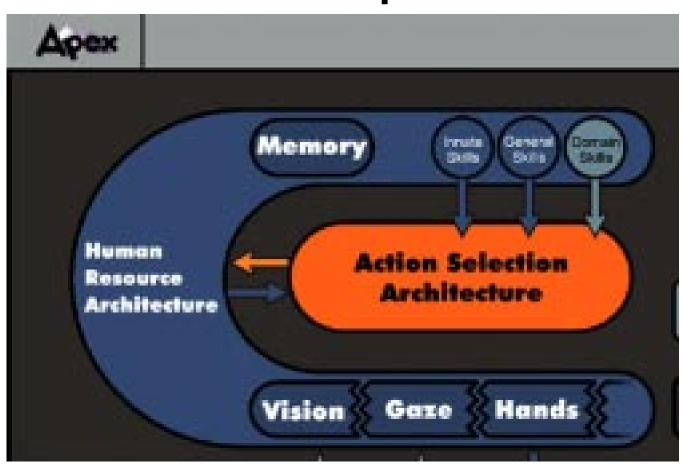


4. Aircraft fails to meet speed target for crossing restriction.

1. FMS transitions out of VNAV when altitude capture achieved.

3. Crew fails to recall B757 transition behavior. Results in "Habit Capture", reversion to B737 FMS procedure.

APEX Human Operator Model



Apex Crew Simulation

- Flight / Cockpit procedures
- Human Performance Model
  - Memory Errors
  - Decision Errors

Human Memory Constraints in Procedure Execution

Dr. Michael G. Shafto, ARC
September 1999

Relevant Milestone: Develop model of human memory constraints in reactive planning and procedure execution (Level 1 Milestone, due Q4, FY99)

Shown: The numbered green text refers to the events leading to an observed overspeed error.The overspeed error is indicated in red text with a line showing the position on the moving map associated with the speed restriction. The large gray arrows show the control flow: APEX Agent interacting with the automation; automation sensing and controlling the aircraft; no direct link between pilot (APEX Agent) and aircraft.

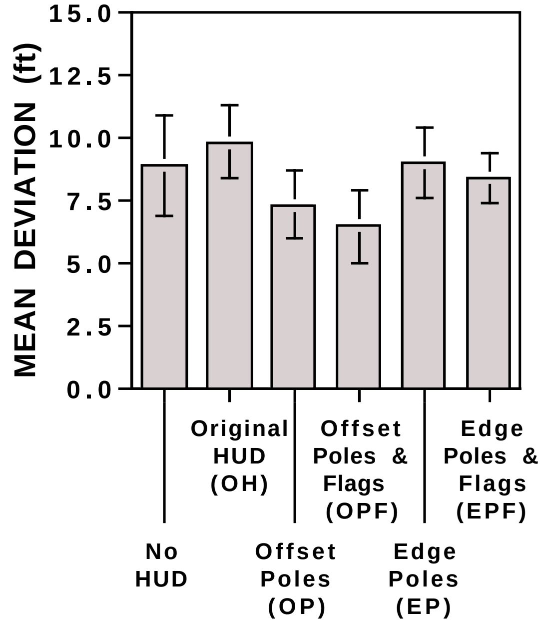
Accomplishment/Relationship to Milestone and ETG:

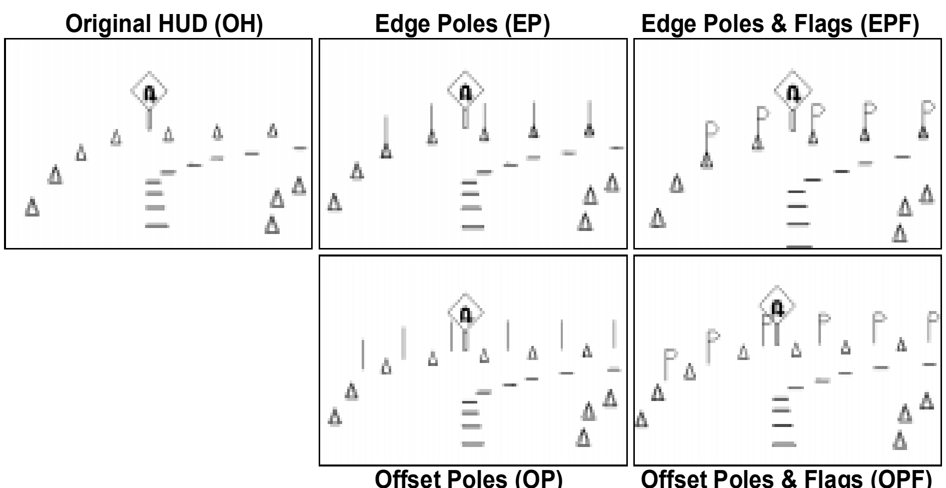
- Analysis and modeling of higher-level planning and decision making abilities used by pilots and air-traffic controllers in complex procedural tasks
- Theory of certain key types of human error based on normal memory processes (predictable vulnerability to error)
- Demonstration of model in analysis of aerospace procedural tasks
- Software available for use; documented in milestone deliverable documents and several peer-reviewed publications
- **Plans:** Port advanced features of APEX modeling approach to MIDAS for AvSP applications. Conduct external evaluations of modeling approach in air-ground automation tasks.

ETG: Reduce the aircraft accident rate by a factor of five within 10 years, and by a factor of 10 within 25 years.

Design of Displays and Procedures

Completed part-task simulator study on Scene-Linked HUD Symbology for taxi turns.





Offset poles and flags placed at a fixed distance beyond turn improves taxi centerline tracking. Pilots can use symbology's relative distance cues to mitigate field-of-view (FOV) HUD limitations.

Design of Displays and Procedures
Dr. Michael G. Shafto, ARC
September 1999

Relevant Milestone: Validate model-based display-design guidelines in part-task simulation (Level 1 Milestone, due Q4, FY02)

Shown: Conditions and experimental results from Scene-linked HUD Symbology part-task simulation.

Accomplishment/Relationship to Milestone and ETG:

- Existing display media and display formats suffer from specific limitations affecting information transfer to the user. Head-up Displays (HUDs) using traditional fixed-location symbology has two limitations: Limited Field-of-view (FOV) and potential attentional fixation on symbology.
- Scene-linked symbology has been shown to mitigate attentional fixation, but by its conformal nature is influenced by FOV. E.g., In making a turn, with symbology cone markers on the turn edge, one "looks over the tops of the cones", resulting in the HUD symbology being only minimally visible.
- Two general types of symbology modifications (both using vertical extensions) were evaluated: Direct extension (directly attached to the edge cones -- Edge Poles); and, Relative extension (offset at a fixed distance beyond the edge cones -- Offset Poles). Despite that the distance cues were relative, pilots were better able to maintain the taxiway centerline with the Offset Pole symbology, because the entire symbol remained in the HUD FOV.
- This work was presented at the 10th Symposium on Aviation Psychology at Ohio State University.

Plans: Further studies to define the attentional and cognitive limitations and mechanisms with HUD symbology and head-down displays will be conducted.

ETG: Reduce the aircraft accident rate by a factor of five within 10 years, and by a factor of 10 within 25 years.

Maintenance Operations and Training

Dr. Mary M. Connors
Ames Research Center

GOALS and OBJECTIVES

Goal:

To reduce errors and improve performance through a focus on three issues with significant and continuing impact on aviation operations performance: maintenance, fatigue, and training.

Objectives:

- Develop procedures and innovations to clarify the roles and responsibilities of aircraft maintenance teams and provide the tools to reduce maintenance errors.

- Reduce the impact of fatigue and circadian rhythm disruption on flight crews and ATM personnel.

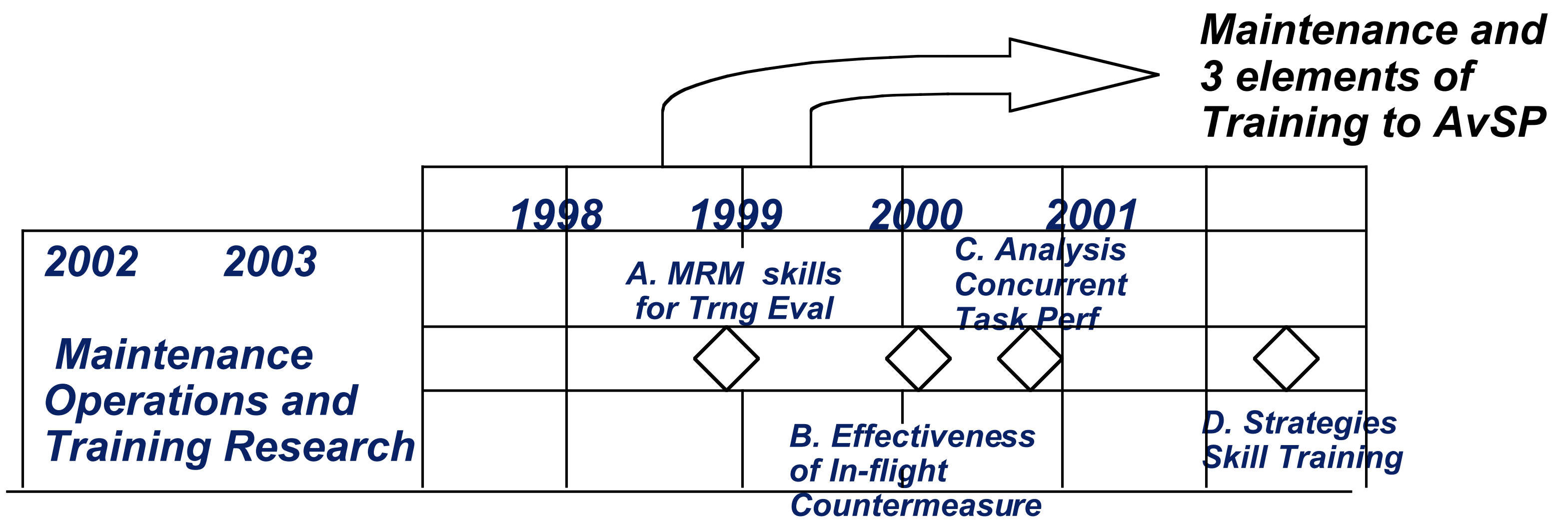
- Develop training techniques that instill the skills required to respond appropriately and quickly to flight-critical situations.

TASK STRUCTURE

MOAT

- **Maintenance**
  - Improved Procedures
  - Human Factors Task Analysis
  - MRM Skills, Training, Eval.
  - Advanced Displays
- **Fatigue**
  - Countermeas. and Perform.
  - Methodologies and Metrics
  - Operational Outreach
- **Training**
  - Weather
  - Automation & Sim. Dev.
  - Assess. of Training Eff.
  - Acquis. & Maint. of Skills

Level 2 Milestones

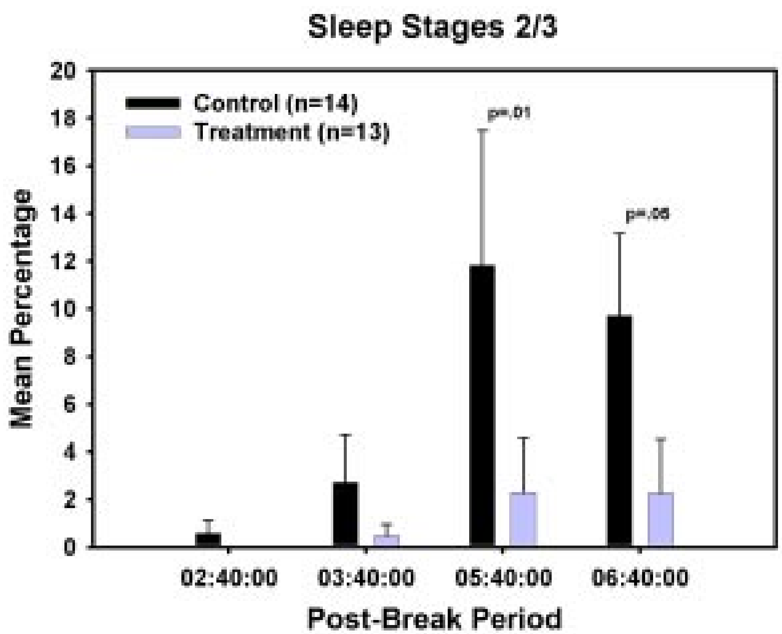


- A. This activity attempts to adapt and apply the capability developed for cockpit crews (crew resource management) in support of maintenance teams. The FY99 milestone to define required skills for maintenance crews is the first step in this process.
- B. Report of in-flight countermeasures investigated as a means of offsetting the effects of fatigue, such as those experienced in long-haul flight. This approach and associated protocols tested in high-fidelity simulation and in the field.
- C. The need to perform tasks concurrently interferes with an individual's attention and memory and, as a result, can adversely impact subsequent performance. This milestone will establish guidelines to address the concurrent task demands present in the modern cockpit.
- D. This milestone provides strategies for improved training of individual and crew skills, e.g., in support of fatigue monitoring and countermeasures, decision making and concurrent task management.

Aerospace Operations Systems Base R&T Program

MAJOR ACCOMPLISHMENTS (FY 98-99)
Fatigue

Investigated means of behaviorally offsetting effects of fatigue. Directed towards Level 2 Milestone, 4th Q. 01.



- Completed data analysis and first draft of activity study.
- Completed data collection, initiated data analysis of study of the effects of feedback.

Aviation Operations Systems
Technical Accomplishment

Fatigue
POC:David Neri/ARC
September 1999

Relevant Milestone: Effectiveness of In-flight Countermeasures (Level 2 Milestone, 1st Q., FY00) (Program Milestone)

Shown: 1) Result from activity break study showing mean percentage (+1 s.e.m.) of stage 2/3 sleep during the 15-min post-break periods (corresponding time periods for Control Group). (2) Flightdeck photo showing PERCLOS cameras and feedback displays in feedback simulation study.

Accomplishments/Relation to Milestone and ETG:
Electrophysiological and subjective data from the activity break study indicate that brief hourly activity breaks reduce nighttime sleepiness for at least 15-min (and perhaps as much as 25 min) especially during the time of the circadian trough. In addition to being effective for moderate time periods, activity breaks as a fatigue countermeasure are practical, operationally feasible, and valued by flight crews. Analysis of the effects of alertness feedback on performance and of the feasibility of an automated alertness monitoring system are ongoing.

Future Plans: Future work will focus on continued development/evaluation of automated alertness monitoring technologies for the flightdeck and the development of models to predict the alertness and performance of flight crew based primarily on prior sleep information and estimates of circadian phase.

ETG: Reduce the aircraft accident rate by a factor of five within 10 years and by a factor of 10 within 25 years.

MAJOR ACCOMPLISHMENTS(FY 98-99)
Training

Icing Video (Level 3 Milestone 4Q '98); Activities in support of concurrent task management (Level 2 Milestone, 4th Q '01).

- **Completed beta version of icing educational video for ice contaminated tailplane stall. Video contains information and graphic depiction on weather conditions conducive to icing; reviewed by customer community; 250 copies distributed (150 requested by FAA/Flight Standards) - '98**
- **Cockpit Interruptions and Distractions article - Printed in Directline and reprinted in numerous airline safety magazines - '99**

Aviation Operations Systems
Technical Accomplishment

Training
POC:Key Dismukes/ARC
September 1999

Relevant Milestone: Analysis of concurrent task performance. (Level 2 Milestone, 4th Q. FY ‘01) (Program Milestone).

Shown: View of typical cockpit requiring simultaneous management of multiple events (right).

Accomplishment / Relation to Milestone and ETO:
NASA Ames scientists, in collaboration with a senior airline captain, published a detailed analysis of ASRS incidents involving interruptions, distractions, and preoccupation with one cockpit task to the detriment of other tasks. This article--Cockpit Interruptions and Distractions: Effective Management Requires a Careful Balancing Act--was reprinted in its entirety by Airline Pilot (which goes to all ALPA members), USAF Flying Safety (the Air Force’s safety journal), USAirways Safety On-Line, Independence (UPS Pilots Association), Flight Safety (Canadian Airlines), and other safety publications. Pilots must frequently manage multiple tasks concurrently. Failure to switch attention among concurrent tasks in a timely manner has contributed to many accidents. For example, the NTSB found that failure of the pilot not flying to monitor and challenge the actions of the pilot flying contributed to 84% of accidents attributed to crew error. The NASA study found that monitoring failures often occur because the pilot not flying is preoccupied with other duties. It also revealed that tasks such as communication--although not seeming to be overly demanding--are frequently distracting or preoccupying.

Future Plans: This analysis of operational issues lays the groundwork for a series of studies that will ultimately provide ways to reduce errors in concurrent task management. We are currently conducting a questionnaire study to determine what techniques highly experienced pilots use to avoid preoccupation. We have begun a laboratory study to elucidate the cognitive processes involved in attention switching among cockpit tasks and the sources of error. These studies will provide strategies that pilots can be trained to use in order to manage attention when performing multiple tasks concurrently.

ETG: Reduce the aircraft accident rate by a factor of five within 10 years and by a factor of 10 within 25 years.

Transfer to Aviation Safety Program

Maintenance

- Definition of Maintenance Resource Management Skills for Training and Evaluation (Level 2 Milestone, FY ‘99)
- KSC task card analysis (tools for procedural evaluation)
- Inspection task interviews at two airlines (Identify high risk tasks
- Incident Analysis - Methods and preliminary analysis
- Analysis of airline and manufacturer engine change practices
- Initiation of prototype design of augmented reality display

Training

- Prototype of model with 1st accident scenario
- 1st draft of proficiency standards for training GA pilots on a PC for crew use of cockpit automation
- Survey and analysis of methods for evaluating crew performance
- Comparison of PCATD and in-flight instrument training effectiveness

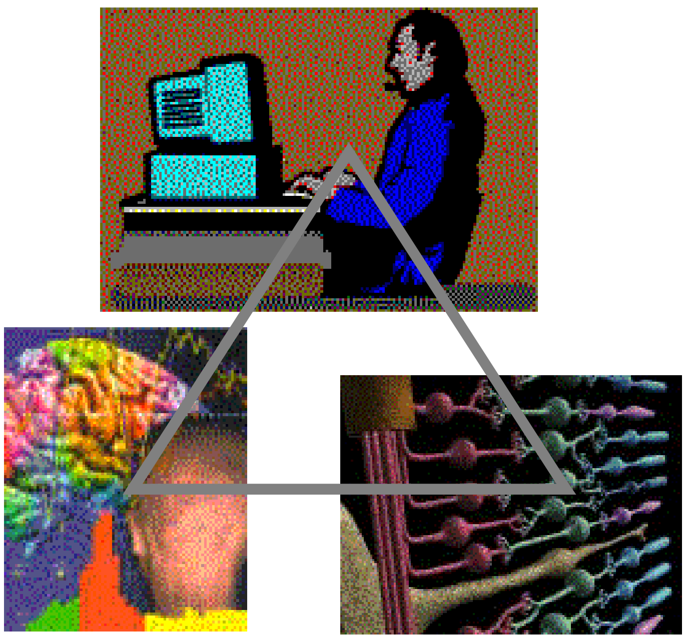
Psychological and Physiological Stressors and Factors

Dr. Leonard J. Trejo
Ames Research Center

Goals & Objectives

Goals

- Supports NASA goal of enhanced safety.
- Seeks new knowledge about human information processing capabilities relating to displays, controls, interfaces and procedures, for safe and efficient management of the increasingly dense air traffic system



Objectives

Develop and disseminate new knowledge in:

- Perceptual Models and Metrics
- Cognitive Models and Metrics
- Physiological Factors

Apply knowledge to:

- Optimize operator interaction with displays and controls
- Optimize operator information processing
- Reduce or prevent hazardous states of awareness

Milestones

L1 Milestone (FY01): Complete guidelines for perceptually matched dynamic 3-D auditory displays and image sensor fusion.

Perceptual Models and Metrics

- FY99 - Collect and report experimental data on perceptual system performance.
- FY01 - Develop computational models and metrics that predict perceptual system performance.
- FY02 - Develop more efficient and more accurate methods for measuring perceptual system performance.
- FY04 - Develop display technologies that exploit understanding of perceptual systems.

Cognitive Models and Metrics (New Safety)

- FY00 - Model the cognitive components of task execution.
- FY02 - Use the model to explore sources of human error.
- FY04 - Explore new techniques for measuring complex performance.

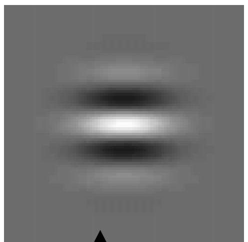
Physiological Factors

- FY01 - Develop and validate methods and techniques for identifying hazardous states of awareness, such as complacency, boredom, and preoccupation, in automated-system design.
- FY02 - Model and predict hazardous states of awareness using physiological and behavioral measures.
- FY03 - Evaluate the effectiveness of countermeasures, including new technologies.
- FY04 - Exploit opportunities to demonstrate dual-use applications of methods, techniques and principles in fields within aeronautics as well as beyond, such as process control and medicine.
- FY04 - Transfer results to operational use through diverse mechanisms.

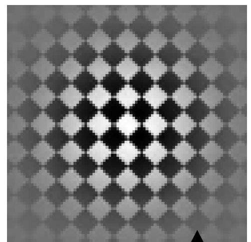
Perceptual Models & Metrics

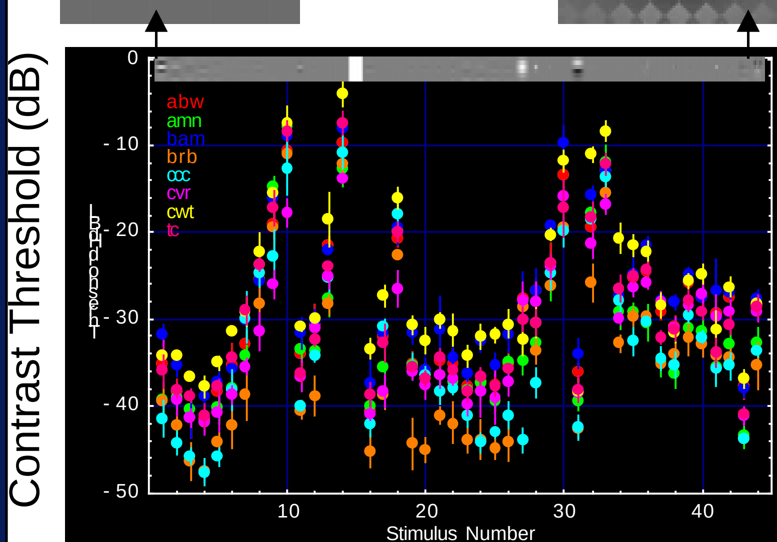
Spatial Standard Observer

- There is a need for a Spatial Standard Observer (SSO) to provide objective measures of visibility and contrast of spatial imagery (e.g., CIE Photometric and Colorimetric Standards)
- Recent multi-lab collaborative data collection (ModelFest) provides a basis for design of SSO
- NASA/PPSF-supported SSO design presented at Optical Society of America (9/26/99)

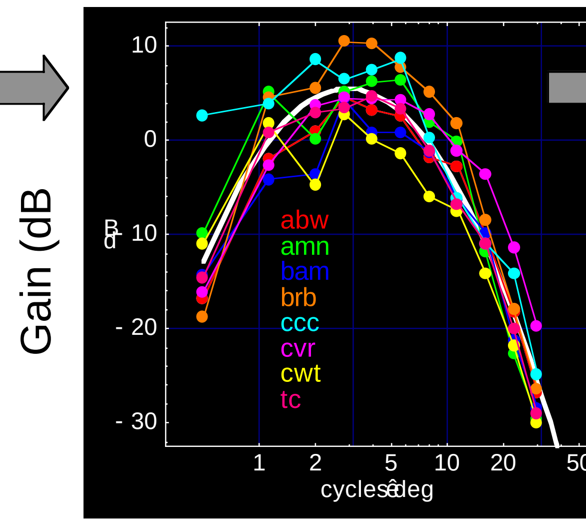


Sample stimuli

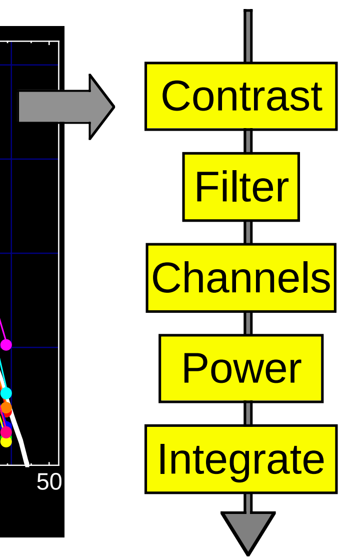




ModelFest Data



Derived Contrast Sensitivity Function



Spatial Standard Observer

J. V. Lebacqz

Perceptual Models & Metrics

Spatial Standard Observer

A Spatial Standard Observer for Aeronautical Displays
POC: Dr. Andrew Watson, ARC
September, 1999

Relevant Milestone: Visibility Models and Metrics Project,
FY02 Public domain distribution of the contrast-gain control visibility model.

Shown: Results of a multi-lab collaborative experiment to calibrate and test models of early spatial vision were used to design a simple Spatial Standard Observer. This measure may be used to describe in an objective, quantitative measure the perceptible difference between two displays. A report on the Standard Observer will be presented to the forthcoming meeting of the Optical Society of America (9/26/99).

Accomplishment / Relation to Milestone and ETG: Development of A Spatial Standard Observer will expedite and standardize the public domain distribution of the visibility model.

Future Plans:

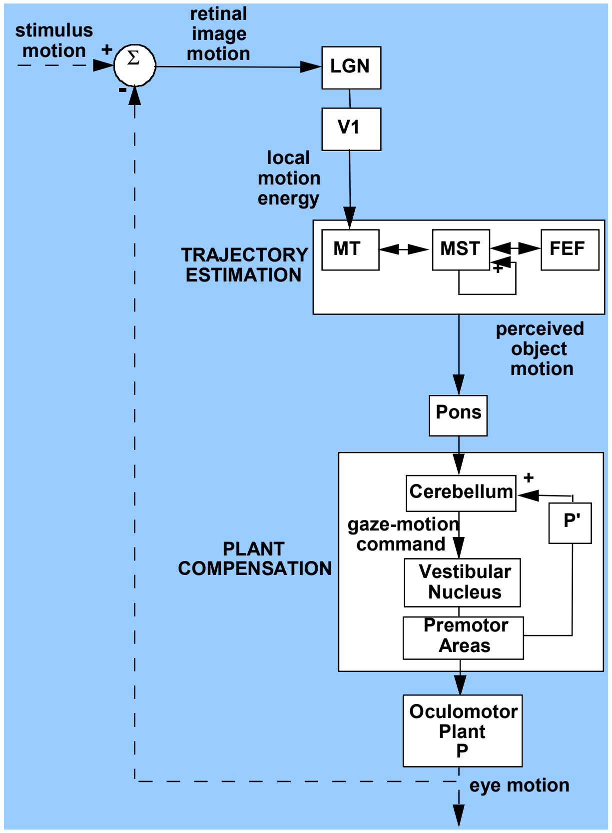
- Augmentation of Standard Observer with masking model.
- Coordination with US and International Standards organizations

ETG: Reduce the aircraft accident rate by a factor of five within 10 years, and by a factor of 10 within 25 years.

Psychophysiological Stressors & Factors

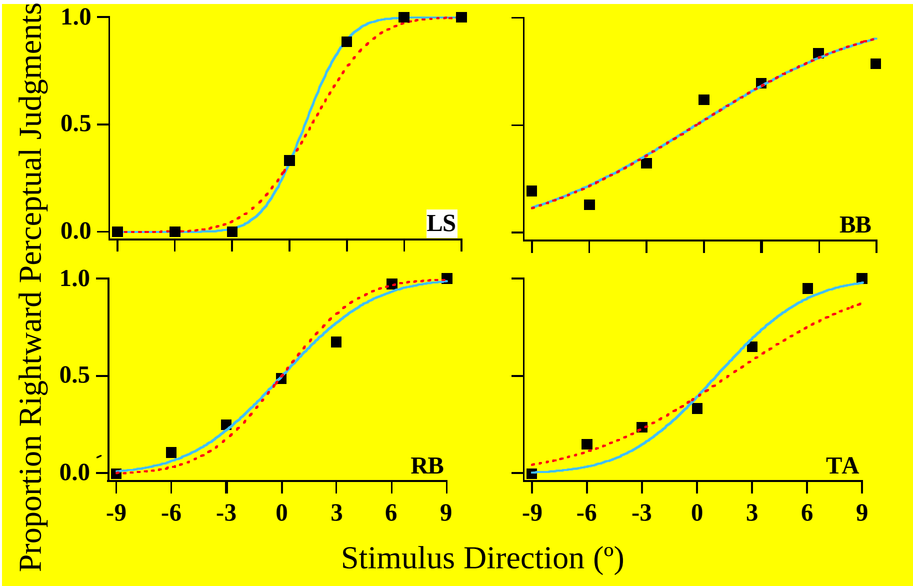
Eye-Movement Models & Metrics

Neural Model



(reported in Krauzlis & Stone, Trends in Neuroscience,1999)

Data & Simulations



(reported in Beutter & Stone, Visual Neuroscience, 1999)

Psychophysiological Stressors & Factors
Technical Accomplishment

Human Oculometric Analysis & Eye-Movement Modeling
POC: Dr. Lee Stone, ARC
August, 1999

Relevant Milestone: Eye-Movement Metrics for Monitoring Human Performance
Collect and report experimental data on perceptual system performance (Level2, FY99)

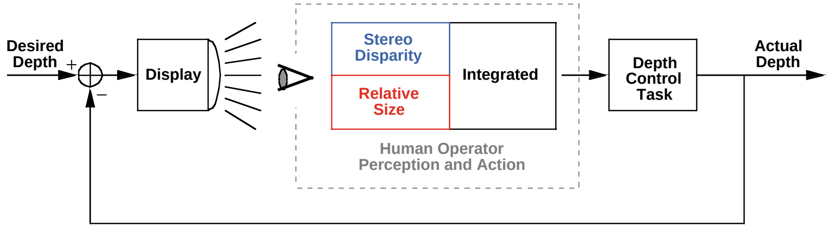
Shown: (Left) Neural model that links pursuit eye-movements and motion perception. (Right) Perceptual data (solid blue lines + black squares) collected from four human operators and simulations of a model that predicts human motion-perception performance from their eye-movement data (dashed red lines).

Accomplishment / Relation to Milestone and ETG: Development of eye-movement metrics (oculometrics) will allow for the non-intrusive monitoring of human perceptual performance during aerospace-related tasks to support training and/or interface assessment/design. Preliminary validation of these methodologies has been achieved through the direct comparison of simultaneously acquired perceptual and oculomotor data in tasks requiring either search (not shown) or motion processing. Development/testing of computational models of the information processing underlying perceptual and oculomotor performance has begun. The FY99 milestone of acquiring, analyzing, and reporting the performance data necessary for the development of new models and metrics has been met.

Future Plans:
- Test and validate models of human tracking and search eye-movements
- Measure and analyze prediction in human eye-movement tracking & correlate with perceptual prediction
- Extend oculometric analysis to include head-tracking & hand-eye coordination in aerospace-related task

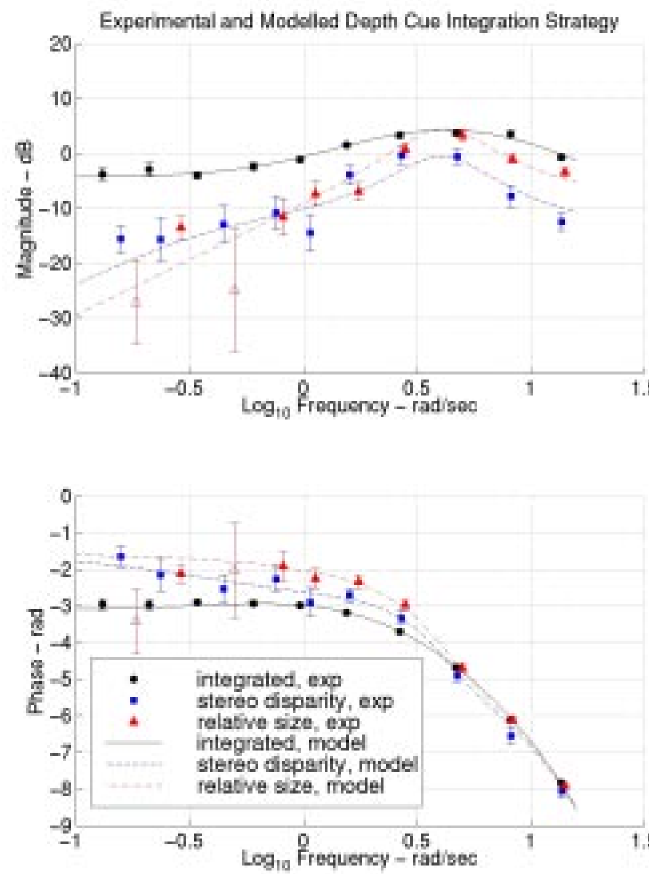
ETG: Reduce the aircraft accident rate by a factor of five within 10 years, and by a factor of 10 within 25 years.

Psychophysiological Stressors & Factors
An Analysis Tool for Human Depth Cue Integration



Model

Experiment



Psychophysiological Stressors & Factors
Technical Accomplishment

An Analysis Tool for Human Depth Cue Integration

POC: Drs. Mary K. Kaiser and Barbara T. Sweet, ARC
August, 1999

Relevant Milestone: Metrics and Models of Range and Closure Perception (Level 3, FY99)
Refined analysis tools for examining depth-cue integration

Shown: A new analysis tool has been developed for modeling human operator performance during active control tasks while viewing perspective displays. An experiment was conducted in which the integration of two depth cues, stereo disparity and size, was examined in an active control task. The results from application of the modeling tool agree closely with the experimental values. The data also indicate that the importance of providing stereo disparity cues is a function of the characteristics of the task being performed.

Accomplishment / Relation to Milestone and ETG: Development of new methodologies to model human operator performance during tasks requiring perception and control of depth. These models are required to optimize design of displays and cockpits when range perception and control is required.

Future Plans:
- Verification of model predictions regarding the effect of task requirements on the performance benefits of stereo displays
- Refinement of depth-cue integration models, through examination of other range and closure cues.

ETG: Reduce the aircraft accident rate by a factor of five within 10 years, and by a factor of 10 within 25 years.

Methods for Analysis of System Stability and Safety

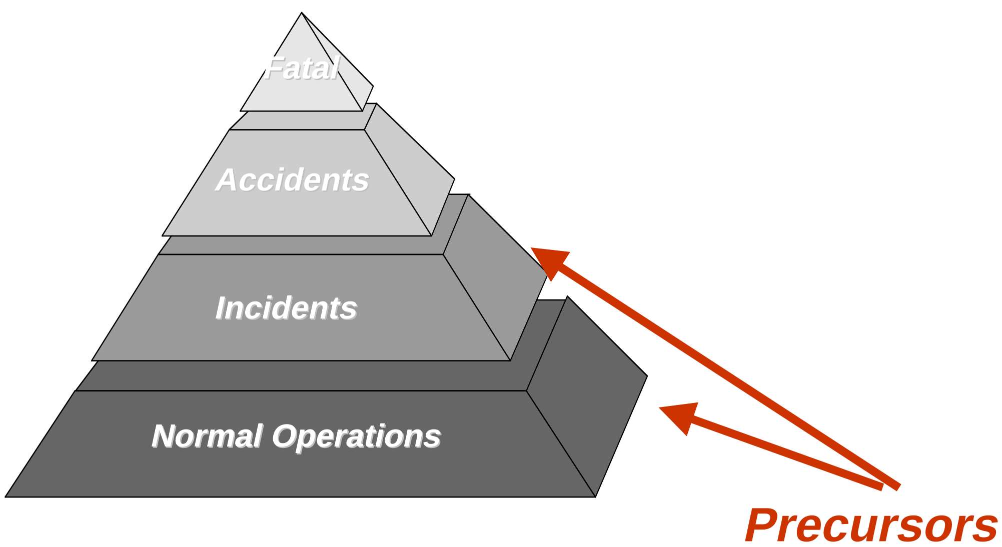
Dr. Mary M. Connors
Ames Research Center

Goals and Objectives

Goal:

Provide the tools for understanding the total aviation system from the baseline perspective (what is happening today) and from the perspective of future changes to the system.

The Operational Pyramid



Objectives:

- Identify causal factors, accident precursors and off-nominal conditions in aviation data
- Provide health, performance, and safety information to aviation decision makers.

Task Structure

MASSS

Data Analysis

Data Analysis Tools (Automated analyst advisor; machine comprehension of text; database linkage; data mining; causal analysis; risk assessment)

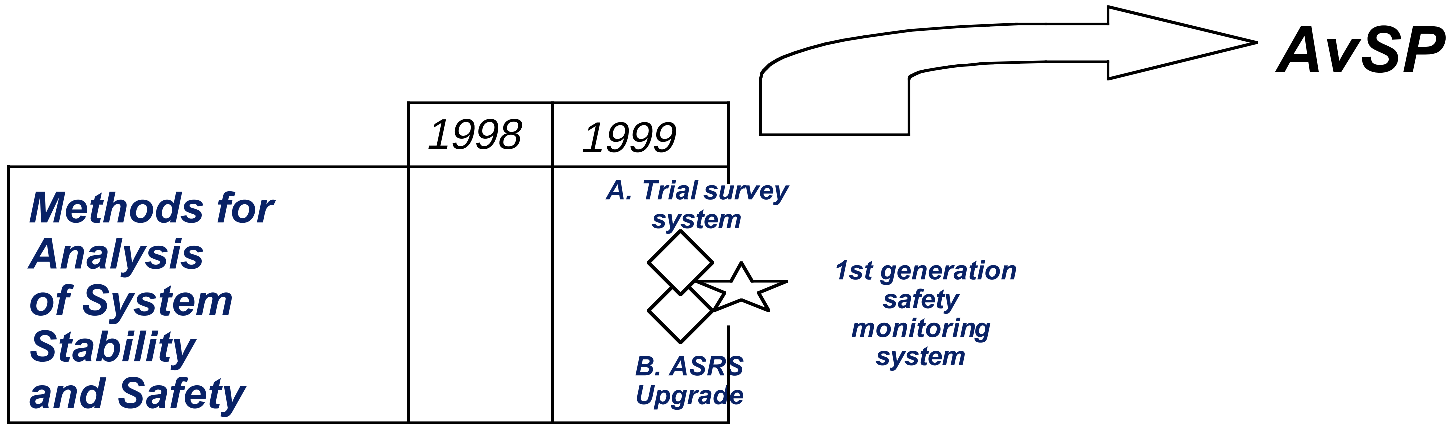
Data Analysis Extensions (Air carrier assessment; ATC Assessment)

Monitoring & Modeling

ASRS Extensions
NAS Operational Monitoring - NAOMS
Modeling and Simulation
Real-Time Demonstration*

* Planned for outyears

Milestones



Level 1 Milestone

Develop a 1st generation, system-wide monitoring capability to measure and communicate the health and status of operational safety performance (FY99).

Level 2 Milestones

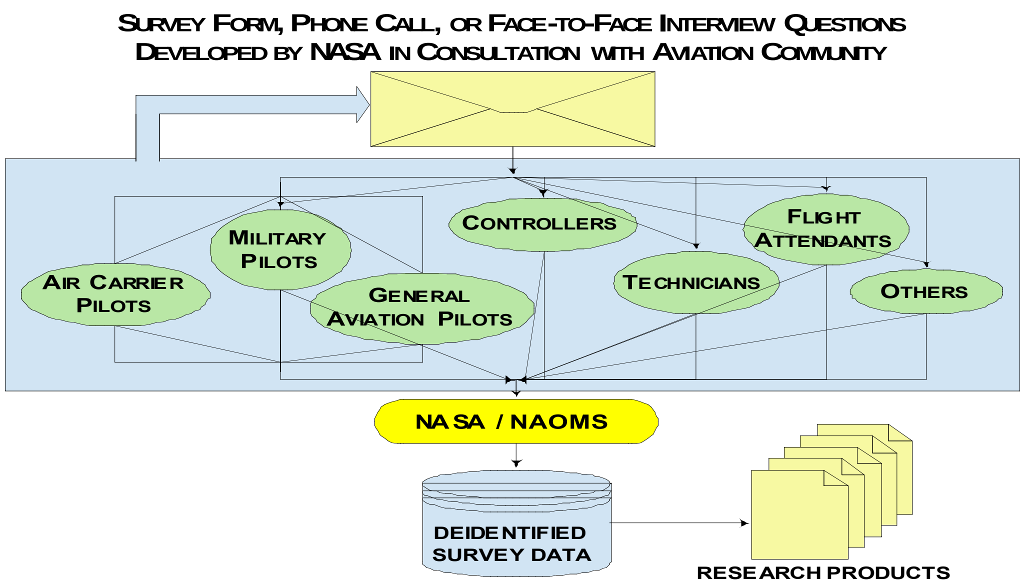
A. **Implement focused trial project of survey system and create 1st generation causal database using advanced coding taxonomies and coding processes (FY99).**

B. **Upgrade ASRS with 1st generation causal database (FY99).**

MAJOR ACCOMPLISHMENTS (FY 99)

Develop a 1st generation, system-wide monitoring capability to measure and communicate the health and status of operational safety performance (Level 1 Milestone, 4th Q FY '99).

The Concept of NAOMS
(NAS Operational Monitoring Service)



<u>National Aviation Operational Monitoring Service (NAOMS)</u>:
Completed study of the demographics of the NAS
Conducted initial studies in support of the NAOMS
Developed survey instrument to tap on-going activities and special interests
Pilot Study - Survey to randomly-selected sample of commercial pilots

Aviation Operations Systems
Technical Accomplishment

System-wide Monitoring

POC:Linda Connell/ARC
September 1999

Relevant Milestone: Develop a first-generation, system-wide monitoring capability to measure and communicate the health and status of operational safety performance. (Level 2 Milestone, 4th Q. FY'99) (Program Milestone)

Shown: Conceptual interpretation of the NAOMS survey as it will function when fully implemented. All elements of the NAS - pilots, air traffic controllers, flight attendants, etc. - will be surveyed systematically, providing a running account of the status of the NAS and any changes that may follow from the insertion of new technologies or procedures. All survey forms will be de-identified to protect the confidentiality of the respondents.

Accomplishment / Relation to Milestone and ETG:
The NAOMS team completed a series of preliminary studies to determine the capabilities of respondents to remember various events, to determine how events are cognitively organized by the population of respondents, and to identify the sampling necessary to achieve statistically reliable results. A survey instrument was designed which taps two major areas: a general section containing questions on various safety-related events designed to be repeated throughout the life of the survey, and a second section addressing a topical area of interest. To address the enterprise goal, it is essential that valid and reliable data be available as to the system-wide status of the NAS. Currently available data systems fall short either because they are not system-wide or because they are not statistically valid.

Future Plans: The field trial, assessing responses to mailed, telephoned, and face-to-face survey approaches, is now being implemented. At the conclusion of the field trial, decisions will be made as to the structuring of the full study, and address any issues affecting implementation. This project transfers to the Aviation Safety Program in FY '00.

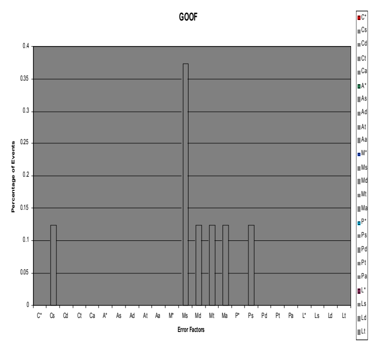
ETG: Reduce the aircraft accident rate by a factor of five within 10 years and by a factor of 10 within 25 years.

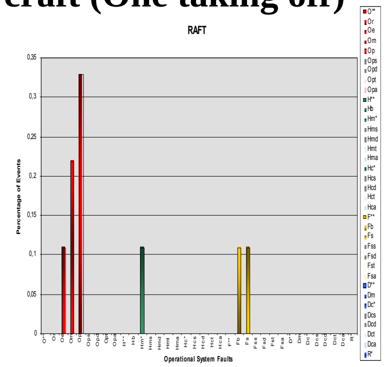
MAJOR ACCOMPLISHMENTS (FY 99)

Create 1st generation causal database using advanced coding taxonomies and coding processes (Level 2 Milestone, 4th Q. FY '99)

Anatomies

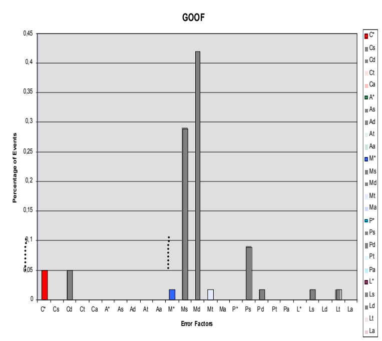
Accidents #2 & 4: Collision of 2 aircraft (One taking off)

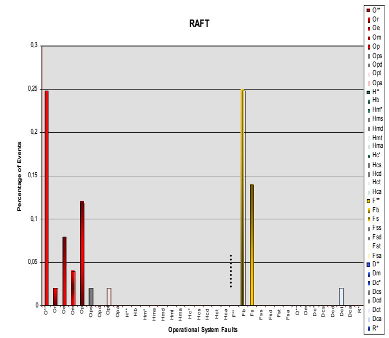




Contributing Factors: Pk

Relevant Incidents





Contributing Factors: Pk, Pg, S, Span

Process entails: Pre-filtering using QUORUM; codification; analysis (anatomy of causal factors.)

Demonstrated process by which incident database can be used to extract information on anatomy of causal factors. This anatomy can be shown to be linked to the anatomy of accident causal factors.

Aviation Operations Systems
Technical Accomplishment

Data Analysis
POC:Irv Statler/ARC
September 1999

Relevant Milestone: Create a 1st generation causal database using advanced coding taxonomies and coding processes. (Level 2 Milestone, 4thQ., FY'99)

Shown: Anatomies of causal factors for accidents and for incidents using the Cinq Demi analysis method.

Accomplishment / Relation to Milestone and ETG:
Demonstrated a first-generation of an effective and potentially efficient process for routinely searching large databases of accident or incident reports and consistently and reliably analyzing them for causal factors of human behavior in aviation operations. Further demonstrated that there are reliable and useful relationships between the causal factors identified from analyses of incident reports and those identified from accident reports.

Future Plans:
(1) Modify the analysis methodology to have it more soundly based on known human behavioral models. (2) Continue to develop the automated capabilities of QUORUM as an initial filter in a search of a large database of incident reports for reports that are relevant to a specific accident or to a specific query on human factors. (3) Conduct a larger-scale test of the linkage of causal factors in incident reports to causal factors of accidents demonstrated in this initial experiment. This project transfers to the Aviation Safety Program in FY '00.

ETG: Reduce the aircraft accident rate by a factor of five within 10 years and by a factor of 10 within 25 years.

Transfer to Aviation Safety Program

Data Analysis

- **Demo capability to automatically search for atypical flights**
- **Demo 1st generation machine comprehension of text tool using QUORUM**
- **Intramurally demo linkage between flight data and textual data**
- **Establish an initial approach to causal analysis**
- **Demonstrate feasibility of performance measures in North/South CA corridor**

Monitoring and Modeling

- **Hybrid database operational for ASRS**
- **Initial test of electronic submission**
- **Completed modeling inventory**
- **Identify relevant modeling requirements**

Outline

Review Context

Program Overview

- Goals & Objectives; Scope; Structure; Milestones; Resources

Program Changes

- Recent Evolution; Relationship to Aviation Safety Program

Project Accomplishments

- Aircraft Icing (AI)
- Aviation Weather Information (AWIN)
- Human-Automation Integration Research (HAIR)
- Maintenance Operations and Training (MOAT)
- Psychological and Physiological Stressors and Factors (PPSF)
- Methods for Analysis of System Stability and Safety (MASSS)

Management

- Management Structure
- Program Assessment
- Advisory Committee Reporting
- Future Plans

Organization

Ames Research Center
Dr. Henry McDonald, Director

AOS Subcommittee,
ATM R&D ESC,
Aero-Space Technology
Advisory Committee

Aviation System Capacity &
Aerospace Operations Systems Programs

Dr. J. Victor Lebacqz, Director
L. Haines, Deputy Director for AOS
F. Aguilera, Deputy Director for ASC
W. Bryant, Deputy Director for ASC/AOS, LaRC
K. Vollrath, Program Integration
Sandra Williams, Resources Executive

Aviation Systems Capacity
AATT: Robert Jacobsen
TAP: Barry Sullivan
SHCT: Dr. John Zuk

Aerospace Operations System
HAIR: Dr. Michael Shafto
MASSS: Dr. Mary Connors
COSTM: TBD
MOAT: Dr. Mary Connors
PPSF: Dr. Leonard Trejo
AI: Mary Wadel (GRC)
AWIN: Frank Jones (LaRC)

Performing Organizations
Ames   Langley   Glenn   Dryden

Program Assessment

	3Q99	4Q99	1Q00	Remarks
Program Overall Assessment	G	G	Y	Budget reduction of $4M in FY00 delays new project start
Technical Performance	G	G	G	
Cost	G	Y	G	Costing of Grants caused cost variance; Corrected by end of FY
Schedule	G	G	G	

Guidance:

Assessment & Performance	*L1 Judgement*
Cost	*-5% Yellow* *-15% Red*
Schedule	*-1Q Yellow* *-2Q Red*

AOS ASTAC Subcommittee Meeting 3-99

- Meeting held March 22-23, 1999 at Langley Research Center
- Results briefed to NASA ASTAC on July 13, 1999
  - **General issues:**
    - √ Significant concern over Base program erosion
    - √ NASA has a legitimate role in applied research, however this should not compromise long-term Base programs
    - √ Additional emphasis should be placed on locating and retaining needed human resources and grooming existing personnel for movement within the organizational structure
    - √ Program briefings demonstrated high quality technical work
  - **Recommendations:**
    - √ Additional funding needed in order to maintain strong R&T Base research
    - √ Aviation Human Factors programs need better visibility
    - √ Individual NASA & FAA Weather and Safety Data Analysis programs are good, however increased high-level coordination between agencies could strengthen both
    - √ AvSP should be assigned review responsibility somewhere within the scope of the ASTAC subcommittee structure
    - √ Clear need for NASA to brief MASSS & AWIN programs to airline constituents
    - √ Human Factors issues and principles need to be emphasized within the MASSS and AWIN programs

AOS ASTAC Subcommittee Meeting 9-99

- Meeting held September 29-30, 1999 at Glenn Research Center
- Observations (unofficial):
  - AOS Level 1 milestones have been met
  - Weather research is very important work
  - Training elements are good, would like more focus
  - Appreciated Vic Lebacqz's review of the last ASTAC Subcommittee's recommendations and subsequent actions taken
  - Liked large amount of industry interaction with projects
- Recommendations (unofficial):
  - Certification issues need to be addressed early
  - HAIR and AWIN briefings should be given to controllers also
  - Need to have good cross-over with work in Aviation Safety Program
  - Need to have a flight facility for icing research, but business case for maintaining the Twin Otter at GRC needs attention
  - NASA still needs to integrate human factors work to preserve their "gems"
  - Use TRL process as Vic Lebacqz outlined it so this Subcommittee can assess "decision gates"

AOS ASTAC Subcommittee Meeting 9-99 (continued)

- Concerns (unofficial):
  - Don't understand NASA's decision process for what gets done where
  - Transfer of some research to Aviation Safety Program may mean that long-term research won't be done
  - Short-term research has been put in Aviation Safety Program, the rest is unclear
  - Don't think that this Subcommittee can accomplish the "goals job" they have been given, this meeting still needs to be 80% technical review
  - Human factors is not being adequately addressed in AWIN, may not be illuminated in the Aviation Safety Program
  - What is left in the AOS Program after all these transfers?

Future Plans

- The goals and objectives of the AOS Program are currently being reassessed in accordance with the FY00 budget shortfall and to better meet the “Aerospace” thrust of the Enterprise
- A new AOS Level 1 Program Plan will be available for review within 30 days of the end of the current Continuing Resolution and upon receipt of format guidance from NASA Headquarters
- Since there are no Level 1 milestones in the April 1998 AOS Program Plan for FY00, the Level 2 Project Managers are writing new milestones, which are due October 15
- Each Project element will generally have one Level 1 milestone each year
- A new investment strategy is required to seed a new generation focus (to support the roadmaps):
  - Human-automated agent Integration
  - Airspace modeling techniques
  - Aerospace applications (e.g. shuttle cockpit upgrade)

AOS Summary

- Completed 100% of GPRA and Program-Level Milestones (OAT GPRA milestone to complete 90% of Program-Level Milestones)
- Major Safety-related Projects transferred to Aviation Safety Program in FY00
  - MASSS
  - AWIN
  - Elements of MOAT
- Met agreement for Tech Transfer to Aviation Safety Program
- Remaining elements provide critical support for Capacity and Safety programs and roadmaps
- Budget reduced $4.3M in FY00; outyear budget not finalized